CERAMICS

DECEMBER
1951

No. 34 Vol. III

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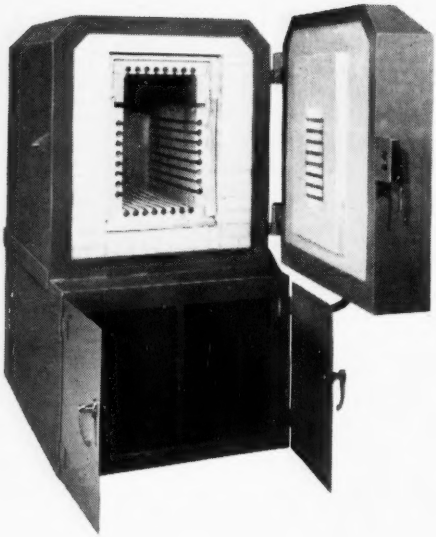

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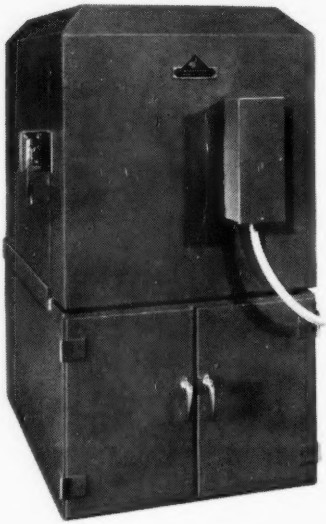

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CERAMICS

DECEMBER, 1951

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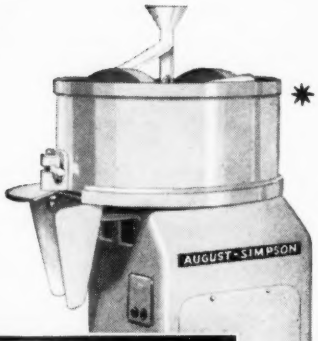

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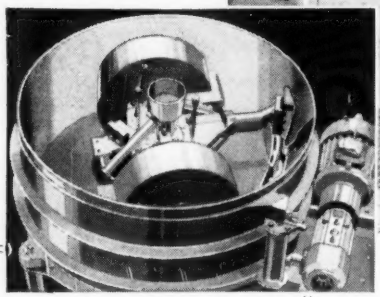

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Ceramics

VOL. III DECEMBER, 1951 NO. 34

CERAMIC INDUSTRY

A Royal Tribute

THE city of Stoke-on-Trent in general, and the British Ceramic Research Association in particular, were honoured by a visit from the Duke of Edinburgh recently. Undoubtedly the popularity of His Royal Highness is such that there are many demands upon his limited time. The fact that the pottery centre of England was able to welcome him as a visitor is important in stressing the realisation of the tremendous value to Britain's industrial output which emanates from the Potteries.

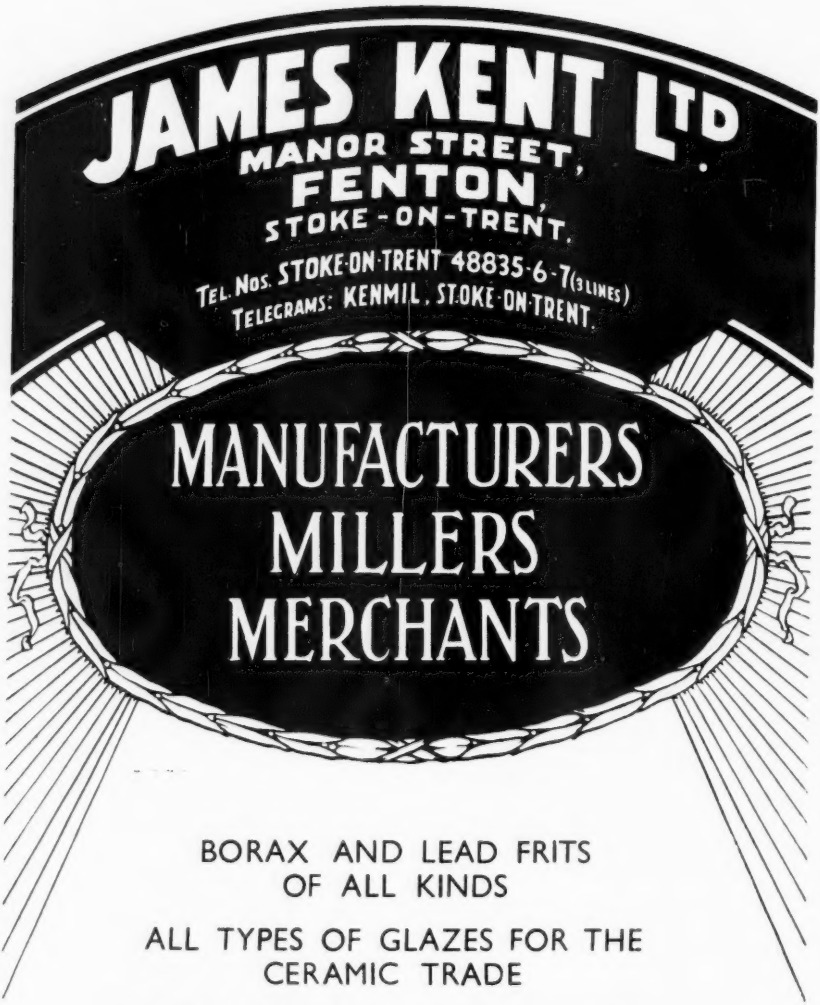
His Royal Highness's visit to the new laboratories of the British Ceramic Research Association draws attention to its importance. From slender beginnings this Research Association has grown until now its total income, as published in February, 1951, amounts to £144,000.

Its object is to carry out research in all sections of the clay-working industries.

The Director of the Association, Dr. A. T. Green, O.B.E., was honoured in having the privilege of showing His Royal Highness around the laboratories and in catching the spotlight of the television newsreel cameras. Bearing in mind that it is only thirty years ago since Dr. J. W. Mellor worked in a wooden shed on the site of the North Staffordshire Technical College with a "Fenton lad"—now Dr. A. T. Green—as his assistant, and the rapid growth of ceramic research is appreciated. Experimentation in a craft industry like ceramics was not viewed with the same favour by the industrialists thirty years ago as it is now, and much credit is due to Dr. Mellor for helping to break down this prejudice.

With the death of Dr. Mellor his responsible work fell to the feet of Dr. A. T. Green. Now Dr. Green is known in the ceramic field throughout the world. It is always difficult to follow any great man—as undoubtedly was Dr. Mellor. The fact that with responsibilities even greater than those of Dr. Mellor, Dr. Green has established himself with a similar reputation, must be very gratifying to the "Fenton lad."

But even so, he has never sought the spotlight of fame and has always been content to let his reputation stand or fall by the quality of the work he has undertaken.



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Research—The Lighter Side

by ARGUS

ONCE upon a time people lowered their eyebrows and tried to escape the enlightened conversation of the clever people known as research workers.

Now the popular press, *Reveille*, and a variety of like educational influences have created between them a layman's university. Why, even the habitué of the four ale bar is prepared to talk on science with a high degree of acquired knowledge! Yet there is a lot in this research business. You can have fundamental research where the chap concerned comes into the laboratory one morning with a kind of eternal question of "What shall we look for this morning, George?"

And again there is applied research! Here one imagines the same bemused researcher arriving on Monday morning with the message before him, from the sales manager: "I have read what you did last week, George. Would you apply it to something we can sell?"

Operational Research

Operational research came into vogue during World War II. Here lots of people often risked life and limb to carry out the most absurd aerial tactics almost reminiscent of the Charge of the Light Brigade, and when they came back odd operational research bods sat around and asked them questions. Since the latter had been drinking coffee or light ales for 3 or 4 hours, and since the former had been doing the risking, the questions and answers were not on a quite related plane, so that the researchers were able to draw the most erroneous conclusions based upon fictitious facts. "Perfect old boy! Right down the factory chimney," said the R.A.F. to the boffins.

Before the war, I mean the second war, the research laboratory was something the managing director showed his visitors in a factory tour, and the folks inside this laboratory were looked at rather like the monkeys in the zoo. But even so they were mostly private laboratories and the mundane balance sheet at the end of the year rather kept the managing director in check so that he was not able to spread himself too far on what he viewed as a luxury sales attributable.

Unfortunately for him he did not see the shape of things to come, for in the close confines of their laboratories these researchers multiplied themselves by fission.

Science—A Money Spinner

Then came the great social revolution of 1945 and two things happened. The universities which had been looked upon by sordid commerce as a rather peculiar organisation tolerated because of the cultural values they endowed, decided that science, a thing they once despised and which took them about 100 years to adopt, was a worthwhile money spinner. They edged themselves into the Privy Council; likewise they encouraged their pupils, mostly psuedo scientists masquerading as economists, to get cracking.

And so in the social revolution the universities opened their doors to the blacksmith's son as well as my Lord Tomnoddy—which made Tomnoddy a teacher and the blacksmith's son a Lord! They started to turn out scientists to the tune of about 50,000 a year. Simultaneously this laboratory which was once an expensive luxury, the overheads of which were paid for by a single firm, became adopted by a government, and so great kudos came to the feet of the universities who thought of the idea, and the researchers who were employed in lucrative positions and to the politician who thought he would use them for his own purposes.

Then came the turn of the half century! The awful discovery was made that Great Britain Ltd. like the coal mines of 1925 was living on its losses. This was indeed an *impassé* The story of the future has not yet been written for it is unwise to anticipate history, and the contemporary raconteur must never blackleg any more than the historian. Horses for courses is fair and reasonable.

Of course there are a few problems confronting the ordinary sort of chap running a business. He cannot get chromium or nickel or copper or what you will. He scratches his head, ponders awhile and eventually thinks "By jove, we have got a lot of tame scientific chaps next door—I will call them in." But here indeed he commits a grievous error almost amounting to sacrilege. He forgets that the reason why those chaps are living next door in the sulphuretted atmosphere of their laboratory is because they do not wish to soil their minds with sordid commerce.

To ask them to solve a question directly related to the production of more or less commodities for sale is like preaching temperance to the brewers' society. After all have they not been trained to study objective fact and do they not expect their livelihood in return for having made the study? They are quick to point out that an investigation such as is required needs a research programme; and research programmes take 12 years to decide, and 20 years to work upon, before the interim report stage is reached. After all science took a long time to unravel the mysteries of the universe so it is rather unreasonable to expect results by the end of the week.

An Escape Route

The unfortunate managing director who calls upon his laboratory to solve an immediate problem finds himself in a cleft stick. There are many avenues of escape open to the scientist confronted with such a mundane proposal. His mind thinks quickly to that electron microscope which would be a handy thing to have about the place. He prefaces his comment with the statement: "Well, sir, it is difficult for us to get an immediate answer, but if we had an electron microscope. . . ." Before he has begun the managing director finds he has landed himself with a thousand or so in capital expenditure at a time when he was setting out to save money! So if he is wise he does not call them in, and if he does he soon sends them out.

What indeed would these research workers do if there was nothing to research upon? Alas, they would be driven to the penurious occupation of teaching small boys that $2H_2 + O_2 = 2H_2O$. For that is all they have been taught themselves, and unfortunately that is all they could otherwise do.

They have had their ups and downs, for once about 1931 you could buy good chemists fairly cheap in the summer season when the universities were regurgitating their content. The best were snapped up, and as the months rolled on, like the fish that had been kept in the "fridge" they became of lesser quality. But today they have profited by this weakness of the past and have made friends with no lesser personages than the Privy Council.

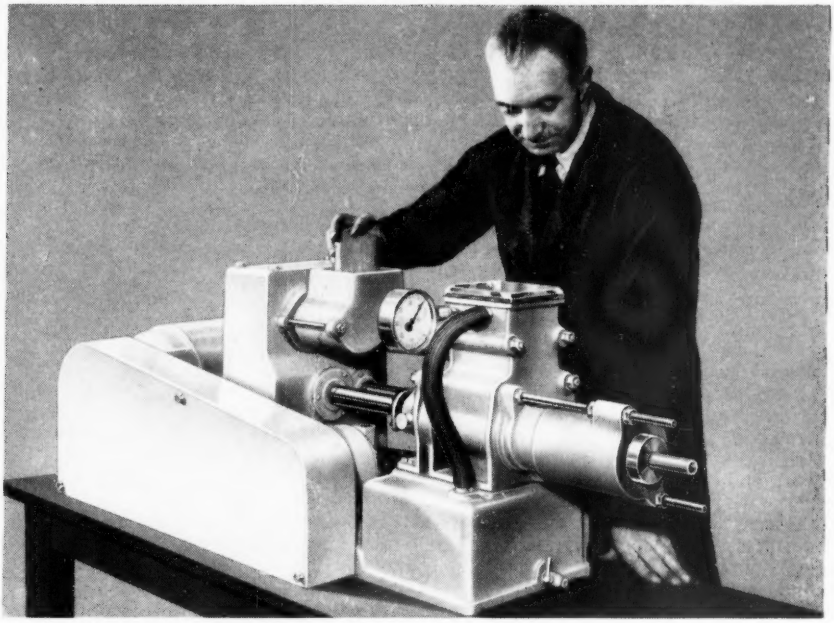
Why, even a professor has become a Crown Minister; a noble lord sets the standard of where they can all go if they play their hand of jokers right!

The best thing to do and by far the cheapest is to accept this race of researchers as being like the poor—always with us. The cheapest and most factual method of dealing with them is to crowd them side by side in the smallest possible laboratory space with the minimum amount of equipment and pay them by results—that is results which can be sold for a profit. It is not easy to do for they have spread their wings and got into all sorts of odd places, like Parliament. They are a force to be reckoned with, for they speak learnedly on subjects like heavy water, and the lay listener imagines he is talking to that rarest of species, the atomic scientist, who either keeps his mouth closed and sits in a job or opens it and ends in Pentonville or Moscow.

The greatest mistake with children is to treat them with the seriousness with which they treat themselves.

Rather it would be that we created a kind of leper's colony—like Harwell—to house them, for after all they must live. Their contact with the

(*Continued on page* 512.)



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Some Developments in the Mixing and Shaping of Pottery Bodies

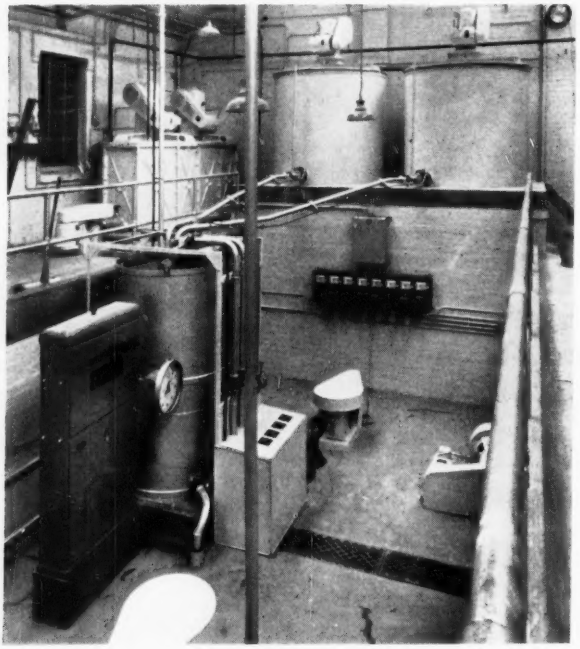
(SPECIALLY CONTRIBUTED)

THE traditional method of body mixing used in this country is a wet one. In the early days the clay was mixed with water and shaped by hand on a potter's wheel. In later times, when the potter became more scientific and began to control the shrinkages and other characteristics of the body by addition of milled materials such as stone and flint, body mixing became a much more involved business involving separate arks for the blunged clay, and a large mixing ark into which the slip was run at predetermined pint weights so as to give a body of known composition.

This method is still widely used at home and abroad, and provided care is taken in running in the slop materials into the mixing ark to the correct heights, gives good results.

Volume-weight Method of Controlling Pint Weight

Comparatively recently it has been realised that some better method of determining pint weight than that of filling a copper pint measure is desirable. In selecting a pint of slip from a vessel holding thousands of gallons it is difficult to say with certainty that it gives, every time, a representative



Modern slip house, showing the tank and weighing machine used for controlling the pint weight of the materials by the volume - weight method

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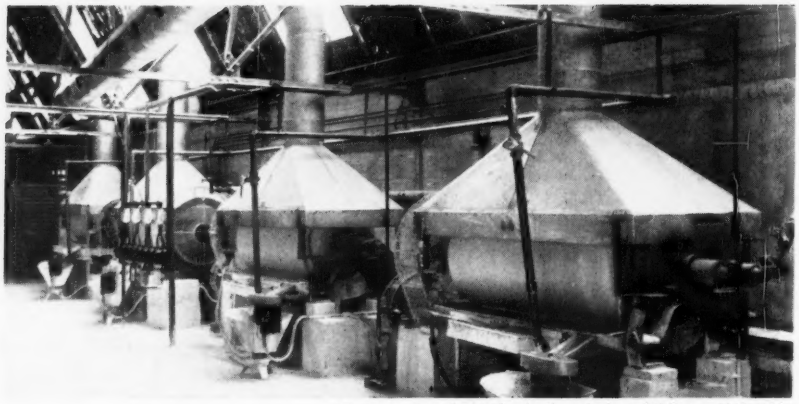


(*Courtesy, Bennis Mechanizations Ltd. and Biltons (1912) Ltd.*)

An installation of steam-heated rotating drums for drying out clay

sample—much depends on the efficiency of the agitation in the ark—and again the error in weighing a pint sample is likely to be much greater than when larger samples are weighed.

In consequence of this the practice of weighing larger amounts of slip is becoming more popular as new slip houses are being built and old ones altered. Briefly the method involves pumping say 200-300 gal. of the slip into a tank mounted on a weighing machine with a dial, weighing up to 5,000 lb. After weighing the slip is returned to the ark. Knowing the weight of the volume of slip (x pints) the weight of one pint can be calculated.

Magnetting and Sifting

Magnetting and sifting call for no special comment except that the modern sieving apparatus, vibrated electrically, is quieter in operation, and the lawns are easier to change when required than in older types. Permanent magnets, thanks to the development of new alloys are tending to return to favour.

Wooden Presses now Going Out

The dewatering of the clay slip has seen notable changes in recent years. Wooden filter presses are now going out of use in favour of the modern iron press containing sixty to eighty chambers. The opening and closing can be done electrically by push button. All that the operatives have to do is to extract the press cakes. A sixty chamber press gives 2½ tons of prepared body at a filling, and a proportionately greater amount for the larger size.

Pumps for pumping up the slip continue to be of the deadweight or centrifugal type according to individual preferences. An interesting development reported recently is the use of compressed air for pumping up the press in place of the usual types of pumps.

Body Mixing in a Ball Mill

For many years Continental porcelain manufacturers have favoured the use of ball mills for mixing their bodies, and this method has also been used to some extent for electrical porcelain bodies in this country.

There are signs of its use being extended to certain other types of body in this country which do not involve the use of large amounts of sticky ball clay. Certainly the ball mill gives very complete and intimate mixing, and when it becomes possible to make dry ground clays available it may be possible to mix the traditional earthenware body in a ball mill, and thus eliminate much of machinery and storage tanks now used in a slip house, with, in addition, a saving in power costs and in space required.

Use of Deflocculents to Speed Blunging

Reduction of the blunging time by the use of deflocculents has been tried on the Continent. Thus in the preparation of vitrified sanitary ware in one factory in Germany the procedure was to make casting slip, not by blunging press cakes with alkali, but by grinding the clays with alkali in a ball mill and then mixing with the non-plastic materials ground separately in another mill. After thorough blunging the casting slip thus made was passed to a storage tank (cf. B.I.O.S. Final Report No. 458, Item No. 22, H.M.S.O.).

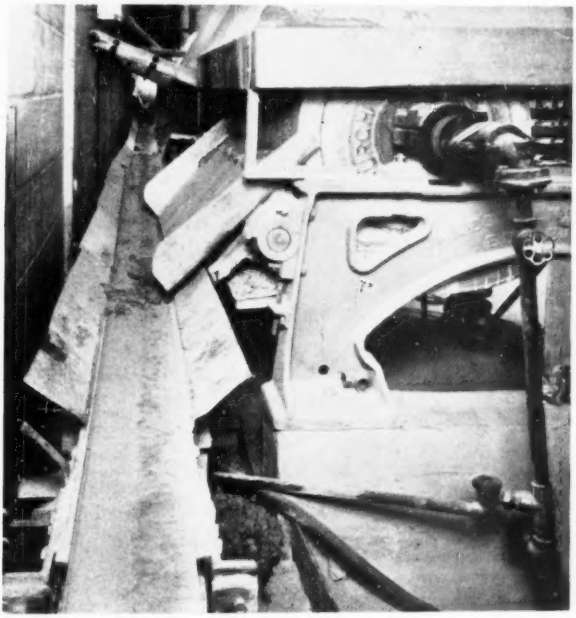
Application of Nylon for Press Cloths

The last war saw a large extension in the industrial uses of nylon, and since 1945 press cloths of this material have been introduced into the pottery industry. Cotton press cloths usually fail as a result of mildew. Proofing with copper compounds increases the life, but the constant washing during pressing operations tends to remove it, and unless the treatment is renewed at intervals, rotting sets in. Nylon is immune to mildew, and its surface is much smoother than that given by cotton, with the result that the press cakes can be stripped off more easily. This again makes washing of the cloths to remove clay easier. This should be done in cold or lukewarm water only.

Proofed jute is still used on the outside cloths next to the steel plates, but experiments have been made with plastic sheets to increase the life of these cloths. In addition to increased life of the filter cloths, the use of nylon enables more trays to be put in the press, with increased output. A disadvantage is its tendency to blow due to abrasion at the tray faces. This occurs more readily than with cotton cloths. The use of a rubber seating for the press cloths overcomes this difficulty (cf. CERAMICS, **3**, 436, 1951).

Dewatering with a Heated Drum

For dust pressed ware, such as wall tiles, a recent process has rendered the use of the filter press unnecessary (cf A. Williams-Gardner, CERAMICS, **1**, 636, 1950). Briefly the process consists of drying out the clay on a rotating steam-heated drum dipping in a trough of the slip so that the body can be removed by a scraper in the form of thin flakes. These are then conveyed to the grinding pan on a



The body is removed from the drum by a scraper in the form of thin flakes and conveyed to the grinding pan on a conveyor belt

(Courtesy, Bennis Mechanizations Ltd. and Biltons (1912) Ltd.

conveyor belt and after grinding the dust is stored prior to pressing.

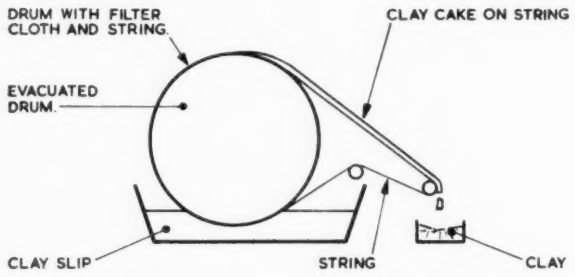
The body slip as normally prepared at 26-27 oz. per pint contains about 45 per cent. water and to evaporate this is unnecessarily wasteful of steam, even though it may be possible to supply some of the requirements from low pressure waste steam. Instead the body slip is concentrated by the use of deflocculents to 35-36 oz./pint, i.e. approx. 25 per cent. water.

Normally on a tile plant the set up is blungers, mixing arks, filter presses, drying room for press cakes, grinding equipment and storage. With the heated drum method filter presses, dead-weight pumps, and drying stoves are eliminated. The body is dried out to the exact moisture content required by varying the speed of rotation and the steam input, and falls off the knife on to the belt conveyor as flakes similar to broken egg shells. On a plant producing 100 tons of dust per week by the filter press method four grinding pans are used. With the heated drum method so little grinding is required that one pan can deal with the same output and there is a saving of at least 18-20 h.p. A comparison of two plants producing approx. 100 tons per week is instructive.

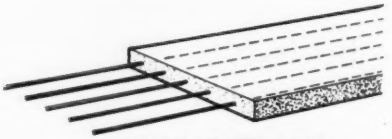
Less Power Required

In the filter press method two eighty chamber presses would be needed with four pumps, needing in all 12 h.p. The press cakes would need trucking to the stoves, and stoving for about 48 hours. They would then be trucked to the grinding pans. About four of these would be required each requiring 6 h.p. motors. This gives a total horse-power requirement of thirty-six and a floor space of about 3,000 sq ft. would be needed for the equipment. Four drying drums 5 ft. 0 in. by 2 ft. 6 in. dia. rotating at 1½ r.p.m., would give the same output operated continuously. The additional equipment required would be four pumps needing ¼ h.p. each, a belt conveyor (1 h.p.) and grinding pan (5 h.p.). The total h.p. requirements would be 13 h.p., as each drum is turned by a 1 h.p. motor. The floor space required would be about half that required for the conventional method of dust preparation. Labour requirements are much less, as the drums operate with very little trouble, and one man can look after four drums while another could keep an eye on the blunger and the grinding pan.

The original models were produced in cast iron, but the drum is now available in a light alloy. This reduces the weight and removes the danger of iron contamination. Such a plant could be placed on an upper factory floor. Low pressure steam at 7-20 lb. is better than high pressure,



Arrangement of continuous vacuum filter



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which bakes the material in the roller, making it difficult to scrape off. An annular type of drum is now available which could be heated by hot liquid. Other suggested uses are the drying of colours and milled potters materials. A possible future development is the use of the heated drum for delivering plastic clay.

The Continuous Vacuum Filter

Drums for delivering plastic clay are in use in some works but are operated as continuous vacuum filters. A vacuum filter consists of a drum perforated with holes of a suitable size around its circumference on which the filter cloth is placed. The drum and filter cloth rotate in a bath of the liquid to be filtered. The inside of the drum is evacuated and water passes into it through the filter cloth on which the solid collects.

To facilitate discharge of this a series of strings are wound around the filter cloth and over a pulley outside the bath. The moist solid collects around the strings and is conveyed by them to the outside pulley, where the change in direction of the string causes the material to be broken off and fall into a bin or on to a conveyor belt (cf. L. A. Mitchell, *Trans. Brit. Ceram. Soc.* **31**, 288, 1932).

This apparatus has found more application in America than on this side of the Atlantic. On many plants in that country, in any case, body mixing is done in the dry way without the problem of dewatering slips. This subject has been exhaustively treated in a recent issue of CERAMICS, and need not be further described.

Shaping of Ware

The three main shaping processes are casting, plastic making, and dust pressing. Let us consider the first method. Casting dates to the beginning of the 18th century. The slip however, was a very different one than that used today. It was made from clay and water, and was so thick that it was scraped up into the mould. These were originally of metal and were oiled to prevent the clay sticking. The use of plaster moulds as we know them dates from 1745 when Ralph Daniel of Cobridge brought the secret of plaster of paris moulds from France. The slips used at that time were made up in water at about 29 oz./pint and

contained much more water than the present deflocculated casting slips. Wear on moulds must have been heavy. At the end of the 19th century soda ash was used as a deflocculent and a mixture of soda ash—silicate was first used in 1905. Other substances used commercially as deflocculents since include sodium tannate and polymerised sodium phosphates.

Recovery of Used Plaster

The possibility of recovering plaster from used moulds has been considered for a long time, and the view that it is not economically possible has gained wide acceptance. A process was worked out in Sweden during the last war but was considered uneconomic in normal times (J. A. Hedvall, F. Sandford, and R. Ahlberg, *J. Amer. Ceram. Soc.* **30,** 323, 1947). This subject has been revived in two recent papers. In one N. N. Fokina, *Stek. Keram.* **8,** No. 5, 17, 1951) it is stated that heating the old plaster at 1·3 atmospheres for 1 hour with intermittent exhaustion of the steam followed by drying at 160° C. for half an hour in the same apparatus is a good method which can be used to regenerate moulds several times.

In the second paper (S. Nagai and M. Sekiya, *J. Jap. Ceram. Ass.* **59,** 141, 1951) the waste plaster is boiled with dilute aluminium sulphate solution. The dehydrate which crystallised was converted to plaster by heating. The regenerated material has a moderate setting speed and the strength of the casts is high.

Attempts to Increase Casting Rate

Various ideas have been used in the attempt to speed up casting rate especially for solid casting. These are summarised in an article by S. S. Kocatopcu (*Bull. Amer. Ceram. Soc.* **25,** 51, 1946). None of these has so far as is known found wide application.

Thus B. J. Allen (*Trans. Brit. Ceram. Soc.* **16,** 134-57 (1917); **18,** 363-77 (1919)) describes a method first used by Regnault, of increasing the casting rate by applying a vacuum to the outside of the plaster mould. Another attempt to increase casting rate was by the action of centrifugal force when the mould is spun (cf P. C. Fritzche, Brit. Pat. 358,363, 1931.) C. R. Austin and G. N. Duncombe, Jnr. (*Bull. Amer. Ceram. Soc.* **20,** [4], 113-6 (1941)) showed that this reduced the casting time of some vitreous dinner ware.

(A. H. Fessler, *Fuels and Furnaces,* **10,** [4] 291-3, 1932) stated that the casting rate could be increased by 75 per cent. by rotating the mould at 1,000 r.p.m. As might be expected, however, this treatment caused some lack of homogeneity in the body, the finer particles accumulating in the face of the moulds and the courser ones towards the centres of the cast. This difference in grain size could affect the shrinkages.

Coagulation of Slip to Speed Casting

Another possibility suggested by A. L. Johnson and F. H. Norton (*J. Amer. Ceram. Soc.* **25,** 336-44, 1942) is to bring about casting by coagulating the slip with suitably charged ions. They suggest that by suitable chemical treatment it would be possible to use moulds of biscuit.

The possibilities of speeding solid casting by inducing coagulation have been described in two U.S. patents. J. M. Lambie and D. W. Ross, U.S. Pat. 1,625,947, 1927, describe the use of a thixotropic slip of high pint weight. This is kept fluid by constant vibration and the mould is shaken during pouring. The slip sets when the shaking is stopped so that the mould can be taken away. A. V. Bleininger (U.S. Pat. 1,528,908, 1925) brought about delayed coagulation by adding aluminium sulphate to the slip, thereby helping it to solidify after pouring into the mould.

Handling of Casting Slip by Compressed Air

Casting slip was originally handled in buckets and jugs, and there are still potteries where this is the method used. Pumping of casting slip has been in vogue for a long time and lately compressed air has been added to the ways of transporting slip (cf C. T. Lyons, *Bull. Amer. Ceram. Soc.* **20,** (9), 321, 1950).

In this method the casting slip is allowed to run into a pressure tank stored underground. This is sloped slightly to allow for complete drainage when required. The tanks used are

galvanized iron, electrically welded and tested to 150 lb./sq. in. Safety valves set at 100 lb./sq. in. are placed in the air feed line, where there is no danger of slip entering them and giving clogging.

The slip is forced through a filter to a height of about 25 ft. in a storage tank holding about 300 gal. The pressure used is 30-50 lb./sq. in. and the volume of slip is lifted in 25-30 min. Slow agitation in the storage tank is employed to force the slip of air. The slip is then fed by gravity into the pressure system for the casting circuit which again employs galvanized tanks and piping tested to the same pressure. For carrying the slip the pipes are 2 or 2½ in. dia. from which drop 1¼ in. pipes feeding 1 in. rubber hose. Two pressure tanks are employed working alternately and the slip is forced out of them by compressed air under approximately 28 lb./sq. in. pressure.

The piping of this system is kept clear by the action of the slip under pressure and after 3 years operation the volume flow was maintained and no build-up was found on inspection. The pressure tanks need cleaning every 3-5 months to clear accumulations—the more use the system gets the less frequently are cleanings required.

The author states that no excessive air entrainment has been encountered using this system and no pinholing that was directly attributable to the changeover to the pressure-casting method. Care must be taken to bleed the lines of air when switching from one pressure tank to the other.

The system is economical in operation as no great volume of air is required and a small compressor is adequate. Troubles encountered with slip pumps as used in the traditional method of handling casting slip are eliminated.

Plastic Making by Hydraulic Press

Plastic making methods have evolved from the throwing wheel through the jolley to the fully and semi-automatic jolleys of today with their enormous outputs. These have been reviewed in a recent issue of CERAMICS (Vol. 3, p. 8, March, 1951) and hence do not need repeating here. Another interesting method for shaping plastic

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bodies is the use of a hydraulic press in conjunction with plastic dies (cf. *Ceramic Industry*, **54**, (4), 127, 1950). The plaster material is made into a thin bat on a spreader in the usual way and this is then placed in the lower die. The piece is then formed by pressure between the two dies. The moisture in the clay is pressed into the die, and the amount left can be varied at the discretion of the operator to delivery pieces which are leather hard or much more plastic. Release of the piece is by the action of compressed air. Normally the piece is allowed to remain sticking to the top die after parting the two halves of the mould, and compressed air blown through the plastic die releases it to the operator's hand.

It is evident that for continuous operation the moisture must be removed from the die. This is done in two ways—by the action of a vacuum leaching moisture from the under surface of the die and also by pressure. From time to time the vacuum is turned off and compressed air is blown into the plaster die. This forces out the water, which is then sponged off the surface of the die. This takes very little time.

It has been found that this method can be applied to making articles which formerly needed casting and that the savings frequently amount to 50 per cent.- There is also a valuable saving of floor space. It is estimated that the press, dryer and other equipment needed for the press method occupy about one half of the space required to give a similar output by casting. This does not include the saving of mould storage space, which in the case of casting is considerable. It is also claimed that plastic pressing done in this way delivers ware practically free from straining and, because of this, losses by warping in drying and firing are reduced. Fired strength is also increased.

It is obvious that production of the dies is of the greatest importance to this process. As a result of improvements made in the direction by using a hard gypsum cement one American firm gets 2,000-3,000 pieces off a die before replacement.

The presses used vary with the size of the article. For small articles up to about 4 in. in dia. such as small dishes, etc. a 4 ton press suffices. Using a larger press (8 tons) it is possible to use multiple dies for small articles, or larger ware such as baking dishes, and scallops. Rolled edged 10 in. platters were produced in a 100 ton press. The firm mentioned in this article found that one man operating a press of this kind produced over two-thirds the daily output of three men making platters on jiggers. It is evident that this is an interesting method of shaping plastic bodies and its further progress will be studied with interest.

RESEARCH—THE LIGHTER SIDE.—(*Continued from page* 502.)

outside world should be reduced to a minimum. Steps should be taken to prevent their reproduction. Then indeed one might find a few people who were capable of working a lathe or a milling machine or even a blacksmith's hammer, for in the end, unfortunately, it is people like these who built the steam engine, who laid the first telegraphic cable, who created the aeroplane, and strangely enough talked to one another across the ether. All these things the research minded folk said categorically were impossible, but when some crazy man with a hammer and chisel did the impossible the folks who said it could not be done were loud in their explanations as to why it was done; and lesser people like ourselves listened so long that we believed that the things had really been done by the folks who said they could not be done!

Safety Goggles.—Industrial eye shields, claimed to give protection without discomfort, have been introduced by J. and S. Newman Ltd., 100 Hampstead Road, London, N.W.1. Under the name "Safespex" they offer unsplinterable and ventilated goggles, toned to individual industrial and institutional requirements such as green for welding, red for X-ray work, grey/blue for sun glare and clear for general use.

DRYING OF IRONSTONE

by

R. C. WALTHEW
(Appleby-Frodingham Steel Co.)

THE purpose of drying the North Hants ores, of which the furnace-burden at the Appleby-Frodingham works partly consists, is to enable the ore to be effectually screened. The average moisture content of the dried ore corresponding to optimum drying is 12 per cent. but may vary from ore to ore. The author describes below the procedure obtaining with both static and rotary dryers and discusses the results from each. Details are given of the heat balance and of operating results, which show that the moisture content of the dried ore from the static dryer was substantially lower than from the rotary dryer, and that the fuel consumption was much higher for the static plant than for the rotary.

Future trends are expected to be in the direction of more comprehensive instrumentation and closer operational control, in view of the importance of ensuring optimum drying conditions and of maintaining a high standard of fuel efficiency.

Drying Requirements

It may at first sight appear wasteful to dry any of the ironstone before charging it to the blast furnace, since it might be expected that moisture removal in the upper part of the furnace stack would be thermally more efficient. Indeed, it is only in the last 16 years that the external drying of some of the ores used at the Appleby-Frodingham works has been developed as part of the general process of conditioning the burden, but results have shown that the indirect benefits in improved working of the furnaces more than compensate for the operating and fuel costs at the dryers.

The blast furnace burden at these works incorporates a mixture of two distinct types of ironstone, namely (1) local ores having low iron and high lime content, and moisture averaging about 12 per cent.; and (2) North Hants ores, of somewhat higher iron content and high silica. These ores, especially in the sizes below 3 in. are of a clay nature and have a moisture content varying between 15 and 23 per cent. according to weather conditions and location of the quarry.

Grading of the ores is an essential feature of good furnace operation, and for this purpose they are crushed and screened to produce a rubble $2\frac{1}{2}$ in. to $\frac{1}{4}$ in. for charging to the blast furnace. The minus $\frac{1}{4}$ in. ore is separately treated for the production of a granulated sinter.

In the case of the North Hants supplies, the combination of high moisture and clay content of the ores as received from the quarry renders it impossible to screen them effectively, and causes trouble in transit to the furnaces due to sticking to hoppers, chutes, etc. Thus it is mainly for the purpose of facilitating the grading and handling of these ores that the method of partial drying has been adopted.

Benefits of Improved Operation

The first dryer was installed at the Appleby-Frodingham Co.'s North Ironworks mainly for the purpose of recovering a sufficient quantity of fines (minus $\frac{1}{2}$ in.) to blend with local ore fines for the production of a satisfactory sinter the blend giving a stronger bond than could be obtained from the local fines alone. The indirect benefits in respect of improved furnace operation were found to be considerable, and G. D. Elliot* has reported the results of comparative tests which showed that increasing the

Paper presented to the Midland and North-Eastern Sections of the Institute of Fuel.

* Iron and Steel Inst., Spec. Rept. No. 30 (1944).

proportion of dried ore in the burden from 10-20 per cent. reduced the coke consumption per ton of iron by 1·4 cwt. This improvement is attributed mainly to the improved distribution of the stock; wet and unscreened North Hants ore gave bad distribution partly because of its tendency to stick to the furnace bell, and partly owing to the angle of repose differing considerably from that of coke, whereas the angle for the semi-dried rubble free from fines more closely resembles that of coke. Furthermore, it is considered detrimental to good furnace operation to have to remove an excessive amount of moisture in the stack.

Main Requirements

To summarise, the main requirement for drying North Hants ore is to remove sufficient moisture to enable the ore to be effectively screened, e.g. without balling or blinding of the screens, and leaving a graded rubble for the furnace free from adhering fines. There is probably little or no advantage in removing more moisture than is necessary to achieve this, and, as will be shown later, more complete drying tends to increase the proportion of smalls and of air-borne dust. The average moisture content of the dried ore corresponding to this optimum drying is usually about 12 per cent. but the correct average figure to aim at may not necessarily be the same for all grades of ore. Hence the main problem of control is to maintain the optimum drying condition (which is probably best judged by the actual behaviour of the dried product at the screens) for the varying grades and moisture contents of the material entering the dryer.

Description of Dryers

The original dryer installed was a static type, comprising two blast-furnace-gas-fired combustion chambers, the products of combustion from which, after air dilution to reduce the temperature to approximately 400° C. were drawn by induced-draught fan through louvres along the sides of two vertical shafts, each approximately 20 ft. high by 7 ft. 6 in. by 1 ft. 6 in. and filled with ore, the gases leaving through similar louvres on the opposite sides. The ore was fed by grab to hoppers above the shafts, and removed continuously from the bottom of the shafts by scrapers on to a plough conveyor, and thence to a ½ in. Gyrex screen for preparation of 4 in. to ½ in. rubble and minus ½ in. to sinter plant.

This dryer normally handled 20 tons/hour of wet ore, with a fuel consumption of approximately 125 therms/hour when drying to an average moisture content of 9 per cent. The shafts held 15 tons of ore, so that the drying time was approximately ¾ hour. This dryer gave good service, but trouble was frequently experienced with clogging and holding-up of the wetter and finer ores. Drying tended to be irregular owing to varying resistance of the tightly packed bed to the passage of the gases, as well as to the uneven temperature distribution across the path of the ore.

Rotary Type Dryers

Shortly before World War II this unit was superseded by two rotary-type dryers, installed as part of the ore-preparation and bedding plant serving the new Appleby-Frodingham South Ironworks. These rotary dryers were designed to handle the minus 3 in. material from all the run-of-mine North Hants ores, this being scalped out and sent direct to the ore-dryer stockyard, the plus 3 in. material being crushed and screened in the usual manner with the local ores.

The ore at the stockyard, which has a stocking capacity of approximately 8,000 tons, is charged by a grab crane into the receiving hoppers at the dryers. Each dryer is rated at 37 tons of wet ore when drying from 19 to 9 per cent. moisture content and comprises a blast-furnace-gas-fired combustion chamber, a rotary drum 7 ft. 10 in. dia. and 43 ft. long set at an angle of 5° driven at a speed of 5 r.p.m., and a discharge hood, with adjustable sealing-rings at each end of the drum. Air for combustion is supplied by forced draught-fan and dilution air by dampers along the sides and top of the combustion chamber, the diluted products of combustion being drawn through the dryer and a cyclone dust separator comprising a primary concentrator and Van Tongeren type of collector, by induced-draught fan. The ore is fed from the receiving hopper by variable-

speed scraper feed into a chute at the drum inlet, the end of the chute terminating near the centre axis. The internal fittings of the drum incorporate the "Buttner" system of lifting vanes and crosses which give a highly efficient distribution of ore in the path of the flowing gases. Final discharge from the drum is controlled by vanes set round the periphery, the angle of the vanes being adjustable, to enable the drum loading to be varied. The normal loading is about 6½ tons, giving a drying time of approximately 10 min. A series of conveyors carry the dried ore to Gyrex vibrating screens and the rubble and fines to the rubble stockyard and sinter-plant storage bunkers respectively.

An essential feature is the maintenance of the inlet chute at a sufficiently high temperature to ensure that the wet ore does not stick and block up the chute. For normal types of ore about 600° C. is adequate, but when feeding very wet and sticky ores an inlet temperature of over 800° C. may be necessary.

Dust Problem

It was soon realised that dust emission and dust handling were to constitute a major problem. Provision had been made for the collection of dust—first, by the ore-dryer cyclones mentioned above, and secondly by a dust-extraction system comprising ventilating hoods at each charging or discharging point in the screening and conveyor system, connected by air ducting to two Van Tongeren type cyclones and a fan.

Not many weeks after the dryers had been started the entire dust-extraction system ceased to operate owing to the ducting becoming completely choked with caked dust. The most appropriate cure for this seemed to be to maintain the whole of the ventilating air carrying the dust and associated moisture in the system, including the cyclones, well above dew-point. For this purpose it was decided to inject hot gases into the hoods so as to raise the temperature of the dust and moisture-laden ventilating air to approximately 50°-60° C. At the same time, to simplify the system, certain hoods not considered important, were cut out. This installation proved successful, and only at very infrequent intervals is it necessary to clean out portions of the ventilating ducts. The problem of satisfactorily disposing of the fine dust collected from the cyclone has, however, always been troublesome on the existing plant. Each ore-dryer cyclone collects about 5 cwt./hour of fine dust and deposits this on the dried-ore conveyor. Much of this dust, together with fresh dust formed or liberated during screening and conveying, is again picked up in the dust-extraction system. The dust collected in the cyclones of this system, amounting to several cwt. per hour, has then to be deposited in such a manner that it does not become a source of further nuisance. Methods of improving the present system will be referred to later.

Operating Results and Heat Balance

The following test on one dryer is typical of normal operating conditions:

The average of 12 per cent. moisture content of the dried ore represented optimum drying for the type of ore used for the test; from other tests on the ore it was shown that a change of only 1 per cent. moisture above or below this average gave a product which was considered by the operator to be a little too wet, or slightly over-dried, respectively.

The moisture content of the screened rubble is higher and that of the screened fines is lower, than the average. Typical figures are: rubble about 14 per cent., fines about 10 per cent. This may be regarded as advantageous, for the following reason: A lump of ore is a clay-bonded aggregate of smaller pieces and, when fully dried, tends to disintegrate owing to weakening of the clay bonds. When dried under optimum conditions these aggregates leave the dryer with only the surface fully dried, so that the strength as a whole is not impaired although the surface will be somewhat friable. Subsequently, however, this surface weakness disappears, owing to partial re-wetting from the interior. Hence, a relatively high moisture content of the larger pieces, i.e. the screened rubble, favours retention of their strength, without detriment to subsequent handling and charging to the furnace. With the fines, however, a lower average moisture content is probably desirable or necessary to

Ore input to dryer	= 38·2 tons/hr.
Moisture content of ore to dryer = 18·15 per cent.	= 22·17 lb. water/100 lb. bone-dry ore.
Moisture content of dried ore = 12·0 per cent.	= 13·64 lb. water/100 lb. bone-dry ore.
Blast-furnace gas consumption	= 103,000 c. ft./hr. at N.T.P.
Blast-furnace gas net calorific value	= 106 B.Th.U./c. ft. at N.T.P.
Temperature of furnace gases entering drum ...	= 750° C.
Temperature of furnace gases at fan	= 107° C.
Temperature of ore leaving dryer	= 70° C.
Atmospheric temperature	= 15° C.
CO_2 content of gases at fan	= 12 per cent.
Volume of dry waste gases at fan	= 324,000 c. ft./hr. at N.T.P.
Weight of moisture removed from ore	= 2·67 tons/hr.
Weight of moisture left in ore	= 4·26 tons/hr.
Weight of bone-dry ore	= 31·27 tons/hr.
Approximate dew-point temperature of waste gases	= 68° C.

Heat Balance	× 10⁶ *B.Th.U./hr.*	*Percentage of heat in fuel*
Total heat in fuel	10·92	
Sensible and latent heat, moisture removed (15°-107° C.)	6·74	61·7
Sensible heat in moisture left in ore (15°-70° C.)	0·93	8·5
Sensible heat in bone-dry ore (15°-70° C.; specific heat 0·2)	1·36	12·5
Sensible heat in dry waste gases	1·07	9·8
Radiation and unaccounted-for losses, by difference	0·82	7·5
	10·92	100·0

prevent packing during subsequent storage and handling at the sinter plant.

A certain amount of mechanical breakdown and production of fines does take place in the dryer, even with normal drying, as shown by Table 1, which gives grading analyses on the ore used for the test quoted above.

TABLE 1.

	Grading analyses on samples of ore (per cent.)	
	From dryer inlet	*From dryer outlet*
Through ¾ in.	45	52
Through ¼ in.	19	24
Dust (below 210 μ)	1	approx. 4

About one-third of the dust (1¼ per cent. of the total weight of ore) is airborne at the dryer outlet, the cyclones at the dryer recovering approximately 50 per cent. and the chimney discharge consisting principally of fine dust (below 20 μ).

In Table 2 the rotary-dryer results are compared with the corresponding figues for the original static dryer. The moisture content of the dried ore from the static dryer was substantially lower than from the rotary dryer. This is attributed to the fact that, owing to the uneven drying in the static plant, it was necessary to dry to a lower average moisture before the whole of the product was in a suitable state for screening.

The much higher fuel consumption in the static plant is accounted for, on the one hand by this higher average moisture removal (over 10 per cent. of the ore, compared with 7 per cent. in the rotary dryer) and, on the other

TABLE 2.

	Rotary dryer	*Static dryer*
Average moisture content of dried ore (per cent) ...	12	9
Fuel consumption (therms per ton wet ore)	2·86	6·20

hand, by a lower thermal efficiency, due to higher waste-gas and radiation losses, as well as more sensible heat lost in the dried ore.

Effects of Over-drying

As noted above, a certain amount of disintegration takes place in the rotary-dryer drum, with normal drying. If the ore is allowed to dry more completely there is a pronounced increase in the production of fines and dust, as is shown by Table 3, which gives the results of a series of three tests on a rough ore with 17·3 per cent. initial moisture content, the three tests being carried out with the same rate of ore input but different quantities of blast-furnace gas:

TABLE 3.

	Test No. 1 Under-drying	*Test No. 2 Moderate over-drying*	*Test No. 3 Considerably over-dried*
Blast-furnace-gas consumption (c. ft.)	60,000	110,000	150,000
Moisture content of dried ore (per cent.)	14·5	9·0	5·3
Grading analyses on dried ore:			
As percentage of total ore			
Through $\frac{3}{4}$ in.	37·0	43·4	54·3
Through $\frac{1}{4}$ in.	12·5	24·1	33·5
Through $\frac{1}{16}$ in.	3·7	16·9	25·3
Air-borne dust (under 210 μ)	0·4	3·3	5·2

Future Trends

The necessity for drying North Hants ore as part of the general conditioning of the ore burden has become so well established that it is intended in the future to dry the whole of the North Hants run-of-mine ores after these have been crushed to minus 3 in. For this purpose there are being installed four additional rotary dryers, which will bring the total drying capacity up to 30,000 tons/week.

In view of the importance of ensuring optimum drying conditions as well as of maintaining optimum efficiency in the interest of fuel economy, the future trend will be in the direction of more comprehensive instrumentation and closer operational control. For this purpose, a central control room at the enlarged plant is being installed, with push-button control of fuel input, primary air, and dilution air, at each dryer, as well as of essential mechanical on-off controls (drums, scraper feeds, conveyors) and full instrumentation — including chart records of fuel flow, and inlet and outlet temperatures—at each dryer.

In addition, it is hoped to investigate the possibility of an overriding control of the dryer fuel input, by means of a photo-electric "eye" in the discharge gases, which would detect over-drying as evidenced by excessive dust emission.

Dust Removal

As will have been gathered from this paper, improvements in dust emission can be looked for in three directions: (1) avoidance of over-drying, (2) more efficient cyclones, (3) more efficient disposal of the collected dust.

On the new plant it is hoped to take care of (1) by closer control, as previously mentioned, whilst provision is being made to cover (2) and (3) by the provision of higher-efficiency cyclones and a different system of dust disposal. This will incorporate dust storage hoppers under the ore-dryer cyclones; from these hoppers the dust will be transported by totally enclosed conveyors direct to a pug mill, from which it will be fed to the sinter plant as a sludge. The collected dust from the dust-extraction cyclones will also be discharged to the pug mill.

Research Problems

It is outside the scope of this paper to discuss the drying of ironstone in relation to general theories and the correlation of actual drying rates with those calculated from small-

scale experiments, and brief reference only will be made to two lines of approach for future research.

First dealing with research on the existing dryers, the possibility might be explored of utilising some property of the waste gases (such as dust content) or of the dried ore (such as moisture content) for automatic or semi-automatic control of fuel input.

Secondly, there is always the possibility of finding more suitable methods of drying or treating ironstone. Before the existing dryers were selected full consideration was given to alternative drying processes and sources of heat, as well as to methods other than drying to obtain a graded product; but it is realised that the possibility of progress or radical changes must not be overlooked.

Acknowledgments

The author wishes to make acknowledgments to the Appleby-Frodingham management for permission to present the paper and to the Engineering Research Department Manager for his helpful advice and criticism; as well as to colleagues in the department and, in particular, to Mr. McDonald of the Blast Furnace Department.

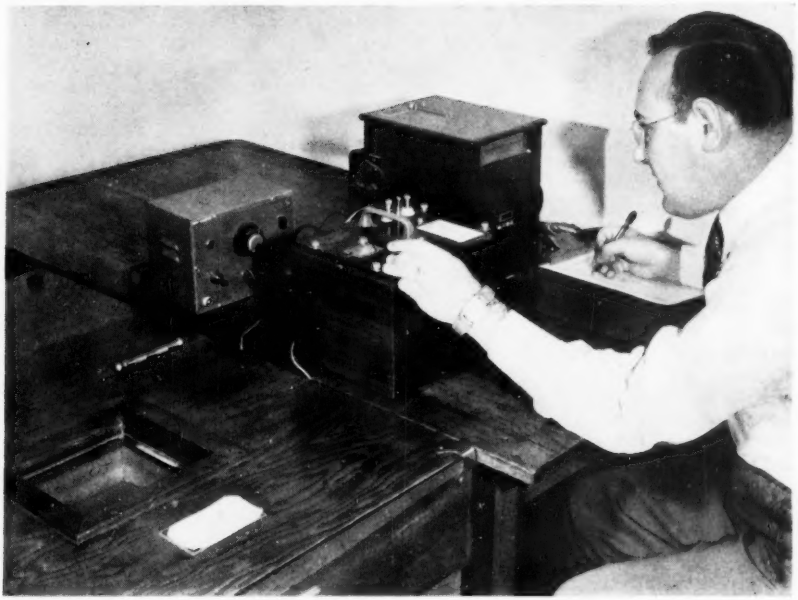
Ceramic Dielectrics for Electronic Signal Devices

Our American Correspondent

THE relation of systematic variation in composition of ceramic dielectrics to their properties is being investigated in the porcelain and pottery section at the U.S. National Bureau of Standards. Such investigations are necessitated by rapid developments in the field of electronics which have introduced operating conditions too severe for electrical insulating materials commonly used as dielectrics. Paper, for example, is a satisfactory dielectric for some types of capacitors, but at elevated temperatures it chars and thus fails. In contrast, ceramic dielectrics not only withstand temperatures of 500° C. and over but, more important, have superior properties making possible a reduction in the size of capacitors compared with those made of paper and mica.

One step in the development of miniature capacitors is the fabrication of ceramics in the form of thin plates comparable in thickness to that of paper and mica. A technique for dry-pressing and firing has been evolved in the production of small plates 0·003-0·006 in. thick. The principal change in the conventional dry-pressing procedure involves special treatment of the mixtures of calcines and bonding agent. With reduction in thickness of plates, it is essential that lumps in this mixture be broken up by passing it through a No. 50 sieve. The resulting powder may be distributed in small quantities in the cavity of the hardened steel mould to form a layer of uniform thickness. A pressure of 20,000 p.s.i. on this layer of powder converts it into a plate a few thousandths of an inch thick. Despite their thickness, these plates are sufficiently strong to be ejected from the mould without cracking and also to be transferred without breakage to a sheet of glass for drying. When dry, the green plates are stacked and stored until needed for firing.

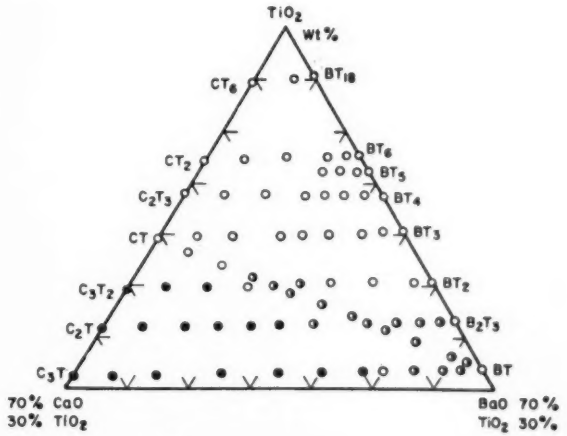
In order to preserve the flatness of the plates during the firing procedure, some changes were necessary in the usual arrangement of the plates on the refractory supports. Excessive warpage invariably occurs if the plates are distributed in a single layer on the plane surface of the refractory. Flat plates are obtained, however, when they are stacked on such a refractory and the stacks are weighed with a refractory



Performance properties of experimental ceramic capacitors at low temperature are studied in a sub-zero cabinet (lower left). The dielectric constant of capacitor plates prepared from barium-strontium titanates was found to range from 12,000 to 18,000 as the temperature in the cabinet was lowered to −60° C. at 5° intervals

disc. To prevent adherence at high temperatures, the stacked plates are separated from each other by thin layers of air-floated zirconium dioxide. Firing for 1 hour at 1,445° C. results in matured plates as indicated by less than 0·1 per cent. of water absorption.

It is desirable that the capacitance of capacitors fabricated from ceramic dielectrics should not be affected by variations in temperature over a wide range, such as −60°-200° C. Experi-



This ternary diagram for the calcium-barium titanate system illustrates the study of the electrical properties for a wide range in compositions. O indicates those compositions which give a decrease in K and Q with time; ◑, a decrease in K and increase in Q with time; and ●, stable compositions. For this diagram B = BaO, C = CaO, T = TiO_2; thus $B_2T_3 = 2BaO; 3TiO_2$

mental capacitors assembled so far, contain plates, 0·75 by 0·75 by 0·005 in., that are composed of a series of barium-strontium titanates with peak values of 12,000-18,000 dielectric constant (K) at 5° C. intervals from −60°-120° C. Such assemblies have a capacitance of 5-15 microfarads per c. in. with a variation in capacitance of 11 per cent. for changes in temperature from −60°-100° C. For comparison, the dielectric constant of paper and mica is under 10 and the volume they require in capacitors for equivalent duty is correspondingly larger. At 200° C., however, the capacitance for the ceramic capacitors decreases to one-third the maximum value and the dc leakage current becomes excessive.

In some instances, designers of electronic equipment have called for the fabrication of a capacitor of given capacitance, temperature coefficient of capacitance, shape and size. This in turn required specific properties on the part of the ceramic dielectric. Several types of single plate and tubular capacitors fabricated have met the designers' specifications. The selection of some of these dielectrics was based upon data recently obtained from the present investigation of the properties of calcium-barium titanate dielectrics.

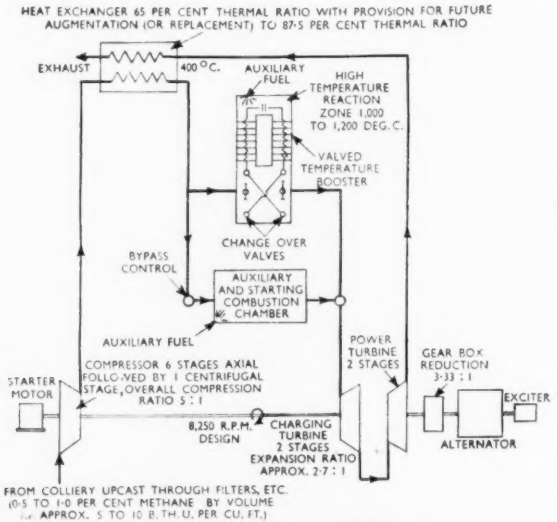
Ceramic dielectrics are applicable to electronic signal devices not only for the armed services but also for the commercial production of radio, radar and television sets, and hearing aids. Other investigators are examining the uses of ceramic dielectrics in research problems that involve very high voltage, X-rays, and instantaneous photography.

Ceramics in a Fuel and Power Project

H. ROXBEE COX, Ph.D., B.Sc. (Eng.), M.I.Mech.E., recently delivered the 38th Hawksley Lecture on the subject of "Some Fuel and Power Projects."*

Work is proceeding on a "firedamp" gas turbine, which is being built by the English Electric Co. Ltd. (Fig. 1). In this connection he said:

There are two novelties in this kind of plant. One is the original notion of burning weak mixtures. The other


HEAT EXCHANGER 65 PER CENT THERMAL RATIO WITH PROVISION FOR FUTURE AUGMENTATION (OR REPLACEMENT) TO 87·5 PER CENT THERMAL RATIO
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AUXILIARY FUEL
HIGH TEMPERATURE REACTION ZONE 1,000 TO 1,200 DEG. C.
VALVED TEMPERATURE BOOSTER
CHANGE OVER VALVES
BYPASS CONTROL
AUXILIARY AND STARTING COMBUSTION CHAMBER
AUXILIARY FUEL
POWER TURBINE 2 STAGES
GEAR BOX REDUCTION 3·33 : 1
STARTER MOTOR
COMPRESSOR 6 STAGES AXIAL FOLLOWED BY 1 CENTRIFUGAL STAGE, OVERALL COMPRESSION RATIO 5 : 1
8,250 R.P.M. DESIGN
CHARGING TURBINE 2 STAGES EXPANSION RATIO APPROX. 2·7 : 1
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Fig. 1. Cycle diagram of 2,000 kW. firedamp-burning gas-turbine set

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is the physical means of doing it—the temperature booster. This device demands in consequence some detailed attention.

A pilot temperature-booster to handle 1 lb. of air per sec. at 5 atm. pressure has been constructed. This is essentially a ceramic regenerator with pneumatically operated mushroom-type valves at the low-tempera-

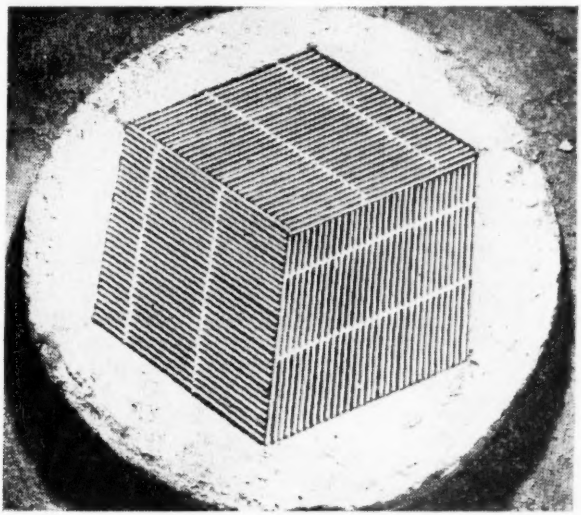


Fig. 2. Layer of matrix in temperature booster

ture ends and with a bridging reaction chamber across the high-temperature ends. The ceramic matrix in each leg is composed of layers of thin high-alumina slats packed on edge with narrow gas passages. One layer is seen in Fig. 2. In the next layer, the slats lie at 60° to those in the first layer. These two arrangements alternate. The firedamp-containing air is admitted through the appropriate valve to the bottom of a leg and proceeds upwards, receiving heat from the ceramic matrix until its temperature is raised to the point at which oxidation of the methane proceeds rapidly. The heat exchanger is so designed that this temperature is reached just before the top of the matrix. The oxidation is completed in the reaction chamber and the air and gas products are raised in temperature a further amount (depending on the original methane content and the proportion consumed).

These hot gases then pass down through the other leg, giving up heat *en route* to the ceramic matrix before passing out through the gas valve diagonally opposite to that used for admission.

After these conditions have continued for a time it will be appreciated that one matrix (on the "air" side) will be cooled and the other matrix (on the "gas" side) heated. Before this cooling and heating has proceeded too far, the flow direction is reversed (by opening the closed valves and closing the open valves). After the appropriate interval, the flow is reversed again, and so on, so that the temperature booster operates as a regenerator with a temperature difference produced by the reaction to "drive" the heat exchanger.

British Pottery Managers' and Officials' Association

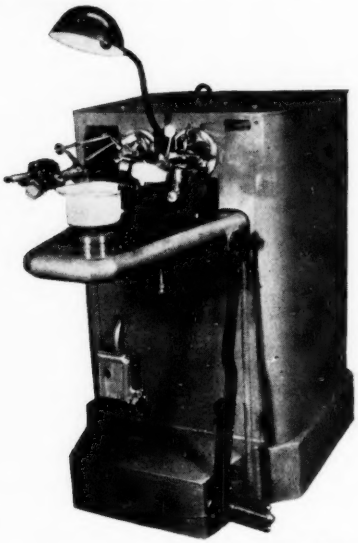
ALL three branches of the Association recently held a joint meeting in Hanley Town Hall, at which six speakers, two from each branch, gave a five minutes' talk, three of them being on tunnel ovens and three on general topics. Each talk was followed by a question time lasting 5 min., and the experiment was so successful that it was unanimously decided to hold further similar meetings in the future.

Mr. H. Hulse, the Association president, was in the chair, supported by Mr. F. Timmins, general secretary, and Mr. J. S. Adams, business manager.

The first speaker on tunnel ovens was **Mr. A. Clough** (of Longton and Fenton Branch) who dealt with the economic aspects, and stated that in his opinion, too much stress was laid on the question of fuel efficiency and too little on that of operating economy. He believed that with a type of oven which was specially designed to give low operating costs even at the expense of it's efficiency as an oven, the total overall cost could be lowered. He gave as the type of oven he had in mind one with a 6 ft. wide cross-section and 1 ft height, with ware being placed straight on to the firing bench, and with a consequent saving due to the absence of superstructure.

Mr. I. R. Forse (of Stoke and Hanley Branch) gave a brief outline of one approach to the question of planning a tunnel oven. He suggested that in addition to the usual facts obtained, a temperature recording should be taken of that part of the existing intermittent ovens which gave the most satisfactory results from all aspects, and that this gradient was re-plotted making due allowance for increased efficiency due to tunnel firing and allowing for a maximum and minimum temperature requirement along it's whole length, a block or tramline curve be drawn to cover the whole range of possible temperature variation through the oven. He suggested that this curve be used to draw a block plan of the proposed oven which would be so many hours long, and which, together with the known output required, would enable the total length and cross-section of the oven and the length of each zone to be estimated.

The third talk on ovens was given by **Mr. Blundrett** (of Burslem and Tunstall Branch). He made a suggestion that in larger factories particularly, economy could be effected by having two types of kiln, one a utility model designed for simplicity and cheapness to be used for the less expensive types of ware produced, with a second oven designed



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specifically for the higher quality class of goods. He suggested that the key to tunnel oven supervision was that of continually checking all dampers, slides, pressures, etc., which should be taken weekly and logged, and all maintenance arranged to a fixed routine. He said that every aspect of tunnels should be borne in mind when planning, and costing departments and other similar departments having indirect but important bearing on the question should all be brought into the discussions at an early stage. It is impossible, he said, to prophesy what any tunnel will do before it is built. The only way was to stick with it until it was working successfully, and then to cry halt.

Mr. N. Proctor (of the Longton and Fenton Branch) devoted his 5 min. to a review of Association affairs. He wondered if the branch lectures were general enough in character, and whether sufficient effort was made to cater for all interests. He suggested that the younger members should be encouraged more to give these talks and to join in the discussions which followed, and that new blood in general be encouraged to enter into the Association affairs. He reviewed the question of wage negotiations, and thought that any manager should be capable of negotiating his own wage questions himself. He hoped that all members would express their grievances openly and not be afraid to talk at meetings and to express opinions. He also asked whether sufficient attention was paid to the question of benefits paid by the Association to members in need of them.

Mr. D. Salt (of the Burslem and Tunstall Branch) devoted his 5 min. to what was in general a humorous summing up of what he thought could be done with the Association funds standing in the bank. Although the whole talk was a light one, and the suggestions were not intended to be considered seriously, he did end up with the suggestion that a travelling scholarship to establish contact with managers abroad should be considered. He also suggested that a conference held on a large scale, of all British pottery managers would be a good thing, and money spent on them would not be wasted.

Mr. A. Seddon (of Stoke and Hanley Branch) used his 5 min. to make the plea that we should still keep secrets in the pottery trade. He said if you find out a new way to do something, hang on to it and don't pass it on. He thought the modern trend in the industry of co-operating and exchanging information was going much too far, and that it would be a good thing to again see the craftsmen with individual knowledge.

THE GAS RESEARCH BOARD

42nd Report of the Refractory Materials Joint Committee: 1950—51*

THE Report mentions work on **A Movement Survey on a Battery of Intermittent Vertical Retorts,** by J. Laming and W. R. Davis. This is summarised as follows:

A survey has been made of the movement of the exterior faces of a setting of intermittent vertical gas retorts, by taking measurements before heating-up, at the beginning of carbonisation, and thereafter at intervals of approximately 6 months during the working life of the setting, which amounted to $5\frac{1}{4}$ years. Measurements of lateral movement were made by stretching wires parallel to the sides of the setting at certain levels, the distance between the wire and the wall being measured at intervals of from 2-4 ft. The relationship between the measurements at different levels was found by plumbing the corner buckstays. Vertical movement was found with the aid of a surveyor's level and staff.

Three main types of movement were observed. Thermal expansion, both laterally and vertically, occurred during heating-up and was followed for several years by a slight growth which was probably caused by the conversion of residual quartz. A second type of movement consisted of a recurrent general tilting of the setting towards the non-producer side wall. Local movements were superimposed on the general tilting.

It was observed that cracks developed within the retorts at a time when the tilting movements were causing distortion of the retorts. The relief of stresses by cracking was accompanied by local changes in the configuration of the side walls and retort tops.

It is suggested that the practice of leaving retorts empty, for the purpose of carrying out hot patching, may have led to the bowing of the retort walls and the consequent hanging of the charge which was observed towards the end of the working life of the setting.

Details, in the form of a progress report, of other investigations on the Gas Research Board's programme are given below:

(1) Further Investigations on Scurf Deposition and the Flaking of Continuous Vertical Retorts

A laboratory apparatus is now in use in which carbon is deposited on the surface and in the pores of various refractory materials by the passage of moist ethylene around the specimen maintained between 800°-1,000° C. During the deposition of this carbon it was found that specimens from silica bricks continuously increased in size, particularly if the temperature of deposition periodically fluctuated over the range 800°-1,000° C. When the carbon was subsequently burnt out by substituting oxygen for the ethylene, the specimens shrank somewhat but did not completely recover their original size. There seems no reason to doubt that a similar phenomenon must take place at the carbonising faces of continuous vertical retorts and it can readily be appreciated that stresses must gradually be set up at these faces eventually leading to flaking.

The cycle of experiments has now been repeated with other refractory materials. Unlike silica specimens, both siliceous and fireclay materials

* Presented at the 17th Autumn Research Meeting of the Institution of Gas Engineers, held in London, 27th-28th November, 1951.

showed a rapid initial contraction during the first few hours of carbon deposition, although this slowly changed to a growth. This growth was much less pronounced with siliceous materials than with silica although after 40 hours' deposition the siliceous specimens had recovered their original lengths and were still slowly expanding. With the fireclay specimens, however, the rate of growth decreased with time, specimens finally becoming constant at a value slightly less than their original dimensions.

Earlier investigations have shown that if the silica specimens are first wet-ground to size before undergoing the cycle of carbon deposition and burning out, such specimens exhibit flaking over the entire surface. Fireclay, sillimanite and alumina refractory specimens, however, exhibit flaking when exposed to similar conditions, while a zircon specimen showed only a few localised areas of flaking. Theoretical considerations have suggested that the tendency for flaking to occur might be reduced if the specimen and deposited carbon have similar thermal expansion coefficients over the temperature ranges experienced in gas retorts. This would now appear to be borne out in practice since fireclay, sillimanite and alumina all have expansion coefficients comparable with that of gas carbon whereas silica has a very much lower coefficient, the expansion of silica materials being negligible above 800° C. The possibility of constructing the flaking zone of continuous vertical retorts with refractory materials other than silica is therefore an obvious line of research.

(2) An Investigation on the Properties of Silica Rocks

It has been reported that there is a lower incidence of flaking in the French carbonising industry compared with the British. Samples of bricks tested suggest that French silica bricks have a higher glass content and a lower porosity and permeability than comparable British products of similar true specific gravity. The differences in texture of the bricks might have their origin in the properties of the raw rocks from which the bricks are made. It was therefore thought desirable to begin a comprehensive study of typical silica rocks in order to ascertain how the properties of the raw materials affect those of the fired brick. Accordingly nine different quartzite rocks were selected for an investigation, six being of British origin, together with two Belgian rocks used in the French silica brick industry and the South African silcrete rock which is now being imported for high-grade silica bricks.

As a preliminary, the porosity, true specific gravity, crystal size, nature of impurities and chemical analyses of the raw rocks were determined. Lump samples of each rock were then heated to 1,420° C. for 16 hours in a laboratory kiln, while others were fired to a standard schedule in a silica brick kiln. Under these conditions the British rocks were by no means completely

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converted and the true specific gravity did not fall below 2·40. The two Belgian rocks which contained large amounts of chalcedonic material showed a higher degree of conversion with densities in the range of 2·35-2·38, while the South African rock had a true specific gravity of 2·33. In spite of this high degree of conversion, the percentage increase in porosity of the South African rock was only 33 per cent., whereas two of the British showed a percentage increase in porosity of over 100 per cent.

In general, rocks with a high initial porosity tended to show a lower percentage increase in porosity on firing than rocks with a low initial porosity, in other words, on complete conversion, all rocks tended to approach to the same limiting porosity. This investigation is now being continued by first crushing and grading the rock and making up sample briquettes, thus simulating silica brick manufacture under closely controlled conditions.

(3) Investigations on Insulating Products

(a) Shrinkage Test

Although insulating bricks give a contraction when exposed to the standard after-contraction test, it was found that similar bricks built into a panel and heated from one face only, often showed an expansion. Over extended periods of heating, however, amounting to 90 hours, the early expansions tend to be reduced and the face may finally show a contraction, although many brands of bricks fail by spalling before the test is completed. It must be emphasised that this contraction is always much less than that occurring in a standard reheat test carried out in the normal manner, and it appears certain that the discrepancy between the panel test and the soaking test would not be eliminated by the time factor.

A comparison of the length changes produced by the panel and soaking tests has been made at a number of testing temperatures. From the results it is tentatively suggested that shrinkage under service conditions, i.e. with heat entering through one face only, may give no cause for anxiety at furnace temperatures that would produce a contraction of 1 per cent., or more in the standard 2 hour reheat test.

(b) Properties of Insulating Bricks After Use

It has often been suspected that insulating bricks deteriorate during use and that a property such as thermal conductivity may change rapidly in the first few months of service. There is little definite information on this point and an investigation has now commenced in which the properties of used bricks are measured and compared as far as possible with their properties before going into service.

The first series to be examined has consisted of high-temperature insulating bricks taken from the wall of a pottery kiln after 6 years' service. With these bricks the thermal conductivity of the working face had increased by some 9 per cent. relative to that of the zone lying farthest away from the heat, although the operating temperature was some 150° C. below the limiting safe temperature of the bricks. In contrast with this result, the thermal conductivity of high-alumina insulating bricks from the hearth of a laboratory testing furnace was found to have undergone a slight reduction. These bricks have been used in a furnace operating at 1,500° C. and it is suggested that a slow solution of corundum grains has taken place, the resulting glass having a lower thermal conductivity than the original crystals.

(4) The Determination of Thermal Diffusity

Attempts have been made to evolve a rapid method of measuring thermal conductivity based on the determination of thermal diffusity. This latter property can be measured with a very simple apparatus involving a heater, two thermo-couples and a galvanometer, while a result can be obtained in 2 hours.

The apparatus gives results comparable with the direct method when firebricks and silica products are measured but a magnesite brick gives results which indicate that the diffusity increases with rising temperature, an observation that cannot be correct. Since the computation of thermal conductivity from diffusity data involves

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a knowledge of specific heats, it has now been decided to remeasure this property. The apparatus is of the conventional type, the specimen being dropped from a furnace into a calorimeter, the rise in temperature being measured by a Beckmann thermometer. It is estimated that with this apparatus the specific heat can be determined with an error of less than 1 per cent.

(5) The Colour of Fired Clay Bodies

Work has continued in this field. In one series of experiments mixtures of china clay with an addition of 10 per cent. of finely divided iron oxide have been heated over the temperature range 200°-1,200° C. at intervals of 100° in atmospheres of (a) nitrogen, (b) moist air and (c) 50 per cent. sulphur dioxide and air. The colours of the specimens were noted after each heat treatment and the state of the iron oxide was ascertained by means of the X-ray. The specimens were next heated at 1,100°, 1,200° and 1,300° C. in oxygen, any colour changes and variations in the state of combination of the iron oxide again being noted. When heated in the atmosphere containing sulphur dioxide, iron sulphites or sulphates were formed at 400°-600° C. and the specimens were grey or off-white in colour. At 800°-900° C. specimens were pink and contained ferric oxide but at higher temperatures the formation of magnetite or hercynite caused the specimens to become grey or black. No compounds containing sulphur were identified after the specimens had been heated higher than 600° C. When heated in moist air the iron remained as ferric oxide, the specimen retaining a pink colour. The nitrogen atmosphere caused the iron oxide to dissociate to magnetite which then combined in part to form hercynite at temperatures above 500° C., but below this temperature the iron was retained in the ferric state and the colour of the specimen varied from pink to brown. On heating in nitrogen at 1,200° C. the specimens became black and vitrified owing to the formation of ferrous silicate glass which crystallised in part with deposition of ferrous

pyroxenes. When these specimens were subsequently reheated in oxygen at 1,100° and 1,200° C. the iron reappeared as free ferric oxide in practically all the specimens, the colour changing to various shades of pink and brown, such differences in colour probably depending on the size of the ferric oxide crystals. For example, if the specimen before oxidation contained magnetite, hercynite, or ferrous oxide glass, oxidation resulted in the formation of finely divided ferric oxide. It was also observed that if the specimens were reheated for a second time in oxygen at 1,300° C. the colour changed to the typical buff associated with firebricks, generally caused by the finely divided ferric oxide entering into solution in the mullite lattice.

The rôle played by lime in influencing the colour of clays containing iron oxide is still obscure but it has now been shown in the laboratory that ferric oxide can enter into a solid solution with the mineral diopside $CaO.MgO.2SiO_2$, the pink colour of the free ferric oxide changing to buff. Diopside can be readily synthesized by heating together an equimolecular mixture of enstatite $MgO.SiO_2$ and wollastonite $CaO.SiO_2$ at temperatures over 1,100° C.

If, however, iron oxide is heated with either enstatite alone or with wollastonite alone at temperatures above 1,100° C. the colour remains pink or brown since ferric oxide does not enter into solid solution with either of these minerals. This observation may be important in further explaining the colour of fired clays since both lime and magnesia in small amounts are present in the majority of fireclays.

(6) Investigation into the Effect of the Chemical Nature of the Crystalline Phase on the Rigidity of the Glass Bond in Silica Bricks

An earlier report has suggested that the high-load capacity of silica bricks at temperatures only 80° or so below the melting point of pure silica is caused by a stiffening of the glass bond due to the presence of crystalline materials associated with it, such crystalline material imposing an orientation of the glass phase which has the effect of greatly increasing its viscosity. An investigation has now been started to explore this suggestion. A pure glass of the composition of the lime-silica-alumina eutectic has been made and thin rectangular rods fabricated from it. The deformation is being measured by flexure when loaded from one end. After measuring the deformation characteristics of the pure glass it is proposed to make specimens containing the glass with suitable crystalline bodies dispersed within it in order to ascertain any changes in the tendency to deform under external stresses.

(7) Investigations on the Clay-Quartz System

Work is continuing at Leeds University under the direction of Professor A. L. Roberts on the relationship between clay and quartz. In the 41st Report of the Refractory Materials Joint Committee a detailed account was given of these investigations which were concerned with the rate of inversion of quartz when heated with small quantities of oxide impurities as mineralisers. The work has now been extended to determine the effect of the grain size of the quartz on the rate of conversion. The results suggested that there was no direct correlation between the original grain size of the quartz and the rate of conversion and it is concluded that either the actual surface area effective in the conversion is not being correctly computed or that the effects due to the mineralisers are predominant. All the results, however, point to the quartz inversion as being a first-order reaction. Studies on the mineralising effect of different fluxes consisting of simple oxides are now being investigated.

J. A. Sugden.—Dr. A. J. Sugden has been appointed research and development engineer of the V.G. Manufacturing Co. Ltd., makers of porcelain and refractories.

Kestner Evaporator and Engineering Co. Ltd.—The company have issued two new leaflets, one (No. 283) describing axial flow fans for corrosive gases and the other (No. 288) acid recovery plant. The leaflets contain all essential details and are well illustrated.

Technical Control in Glass Manufacture

THE following has been extracted from an article, under the above title, by J. H. Partridge, Ph.D., D.Sc. of the G.E.C. Research Laboratories, and E. Preston, Ph.D., D.Sc. F.R.I.C., technical manager, Osram-G.E.C. Glassworks, which appeared in the October, 1951 issue of the *G.E.C. Journal*, to whom acknowledgment is made.

Glass is melted in large tank furnaces of the regenerative or recuperative type, containing from a few to 1,000 tons or more of molten glass, a cross-section of a large glass melting furnace being shown in Fig. 1 (a and b).

Usually the temperatures of such furnaces are measured by platinum/platinum - rhodium thermocouples through the crown of the furnace in the melting end, and by a disappearing filament radiation pyrometer sighted on the bridge wall for daily checks. The temperature charts thus obtained indicate constancy of melting temperature to within ± 10° C. However, such methods of temperature measurement only measure the temperature at a given point in a large mass of material. It is known that, as with any liquid, currents exist in the mass of molten glass and it was suspected that changes in temperature of, for example, the stream of molten glass following on to the refractory sleeve of a tube drawing mandrel occurred which were not indicated by the normal pyrometer equipment of the furnace.

A sensitive photocell type of radiation pyrometer was developed which proved to be capable of measuring small changes of temperature of the surface of a ribbon of molten glass at temperatures ranging from

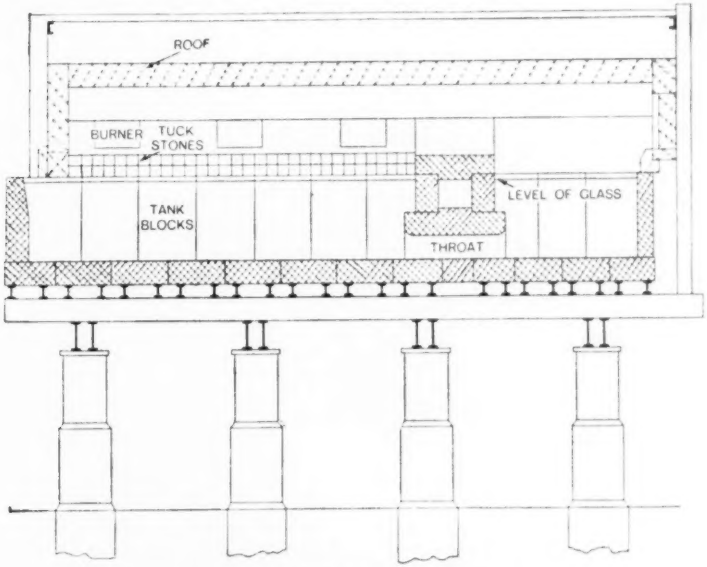

Fig. 1a. Longitudinal section of a large glass-melting tank furnace

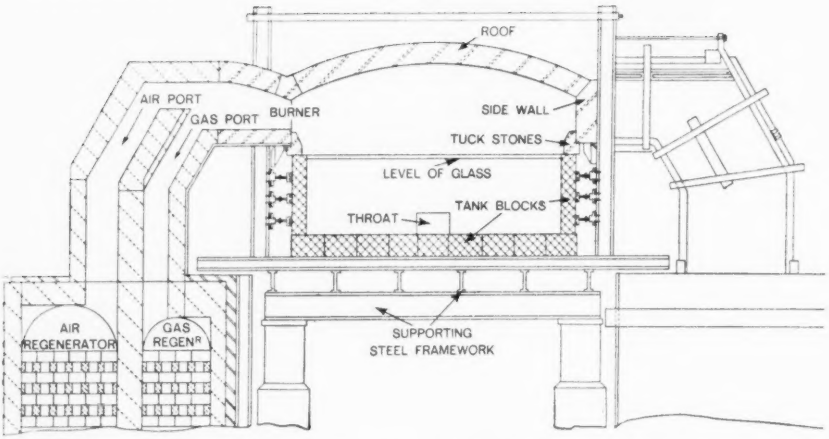

Fig. 1b. Cross-section of the tank furnace

950°-1,200° C., and to plot these results on a time scale.

Photo-electric Pyrometer

Briefly, the photo-electric pyrometer consists of a vacuum photocell, the cathode of which is connected to the grid of an electrometer triode valve incorporated in the same glass envelope as the photocell. When radiation from a hot source falls on the photocell, the voltage developed on the grid of the valve across a suitable grid, leak resistance changes, and alters the current flowing through the valve. The valve forms one arm of a bridge circuit, and the balance of the bridge having been upset, it is restored by

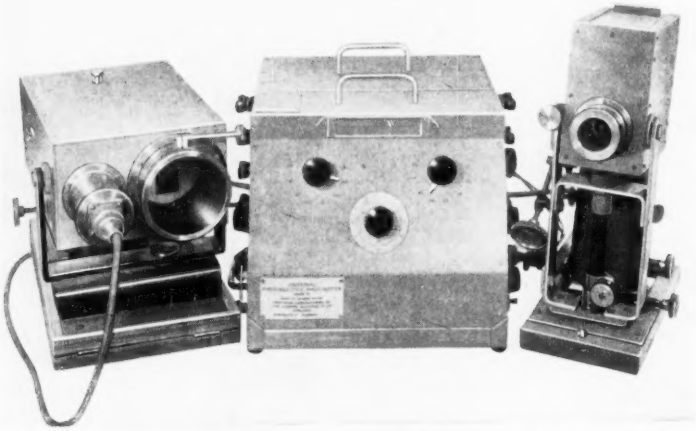

Fig. 2. Photo-electric pyrometer. The tele-receptor unit is shown on the left, the photometer bridge unit is in the centre, while the calibrating lamp is housed in the unit on the right

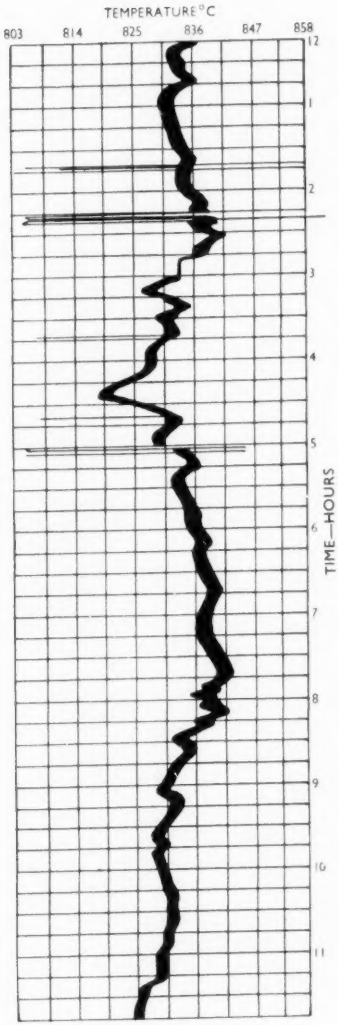

Fig. 3a. Typical chart of ribbon temperature of glass for tube-drawing

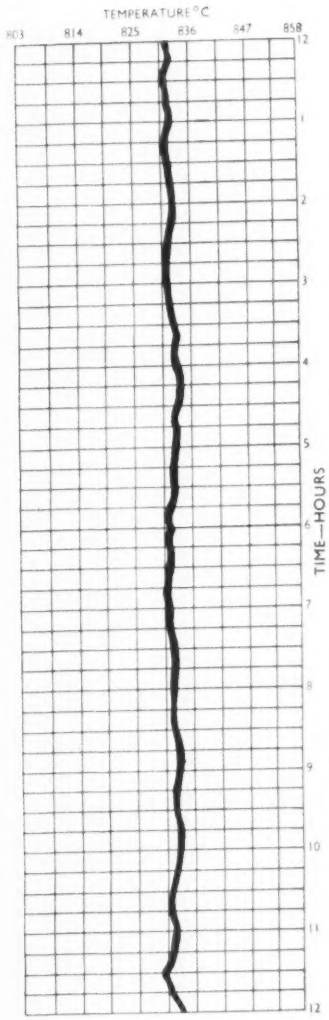

Fig. 3b. Chart of ribbon temperature after regulation of fuel supply and furnace pressure

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applying grid bias from a potentiometer circuit, and adjusting until zero current flows through the galvanometer. The voltage reading on the potentiometer is then a measure of the radiation falling on the cell and hence of the temperature of the hot source. The instrument is calibrated by means of a standard lamp. The pyrometer containing the tele-receptor housing, the bridge unit and the calibrating lamp are shown in Fig. 2. To record continuously the variations in temperature, a recording millivoltmeter is coupled to a D.C. amplifier which is substituted for the galvanometer in the potentiometer unit.

Results of Temperature Measurement

A portion of a typical time-temperature chart (Fig. 3) obtained by using this pyrometer shows not only that the level of temperature changed, but that the temperature of the molten glass changed much more rapidly than had been suspected. This latter result showing extensive short period fluctuations was unexpected, considering that the glass was issuing from a tank of some 80 tons capacity.

A portion of a typical chart at this period (Fig. 3a) showed that the temperature varied from 819°-841° C.; tests extending over long periods of time indicated a standard deviation in the temperature variations of about 10° C.

The causes of temperature variability were traced to variations in oil flow and furnace draught due to the fact that several furnaces were being supplied from a common supply, and the furnaces were exhausted into a common supply, and the furnaces were exhausted into a common stack. Removal of the causes of variability resulted in more uniform temperature of glass as indicated by the time-temperature chart in Fig. 3b which shows a variability in temperature ranging from 828°-834° C. with a standard deviation of between 2° and 3° C. There was a marked improvement in the efficiency of the plant and decreased variation in dimensions of the product.

CLEAN PRODUCER GAS FROM BITUMINOUS COAL

FOR many years gas producers operating on bituminous coal, especially with the non-caking high volatile variety, have proved to be the most efficient means of using this type of fuel, maximum efficiency being obtained when the gas can be used hot. Control, however, is necessarily rather rough, and the needs of industry more and more demand accurate firing conditions which, in turn, necessitate the use of clean gas. To obtain reasonable efficiency with clean gas the tars must count in as a readily saleable or usable product, but the orthodox water washing process for cleaning bituminous gas produces high water content tars which are, more often than not, a nuisance rather than an asset.

The British licence for a new process has recently been acquired by Gibbons Heurtey Ltd., from Heurtey and Cie, Paris. This process results in a 99·9 per cent. degree of cleanliness, giving by-products of good quality pitch and water-free light tar oils. In addition, the sensible heat is recovered from the gas as clean hot water at about 90° C. The overall efficiency is shown in the heat balance

The future of producer gas for firing kilns seems to be firmly established and obviously cleanliness of the product is of extreme importance.

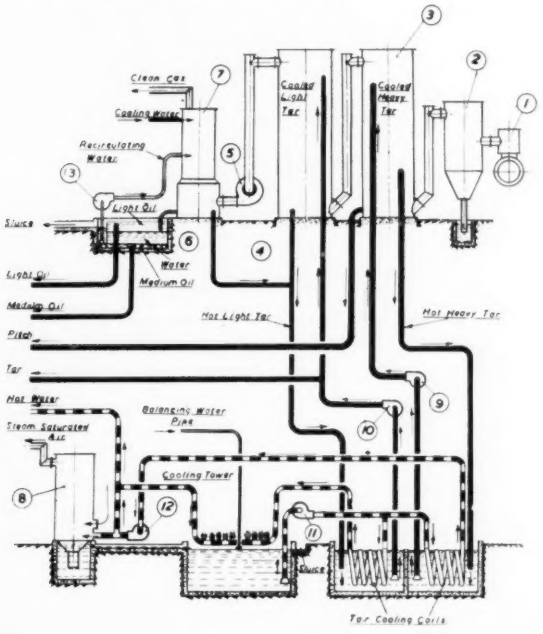

Fig. 1. Diagram showing gas-flow through the cleaning plant

1. Raw gas valve. 2. Dust catcher. 3. Pitch and heavy tar tower No 1. 4. Light tar tower No. 2. 5. Booster. 6. Detarrer. 7. Washer and separator. 8. Air saturator. 9. Heavy tar pump. 10. Light tar pump. 11. Cooling water pump. 12. Hot water pump. 13. Circulating water pump.

Fig. 2. View of the electrically - driven booster fan and of the pipes which convey the raw gas to the pitch column

below from coal of 13,500 B.Th.U./lb.

	B.Th.U.	%
Gas	9,000	66·7
Pitch and Tar Oil	2,250	16·7
Clean Hot Water ..	750	5·6
	12,000	89·0

The Operation of the Plant (Fig. 1)

As a general rule, the hot gas from the producer first passes through a dust catcher (2); this is not indispensable but it relieves the cleaning vessels of the larger dust particles. The dust catcher is lined with firebrick and insulation to protect the steel plates and to keep the gas at the correct temperature for its later treatment; the necks before and after the dust catcher are designed for easy cleaning with the plant at work.

The next vessel (3) is for heavy tar removal, the gas meeting sprays of tar oil which dissolve the heaviest fractions as pitch. This collects in a bath at the bottom of the vessel, where, warmed by the incoming gas and agitated by two heavy horizontal stirrers, it overflows to a water bosh.

In the light oil washing vessel (4) the gas, now at a lower temperature after the initial washing, meets a counterflow of light oil over a series of baffles, which absorb the light tar oil

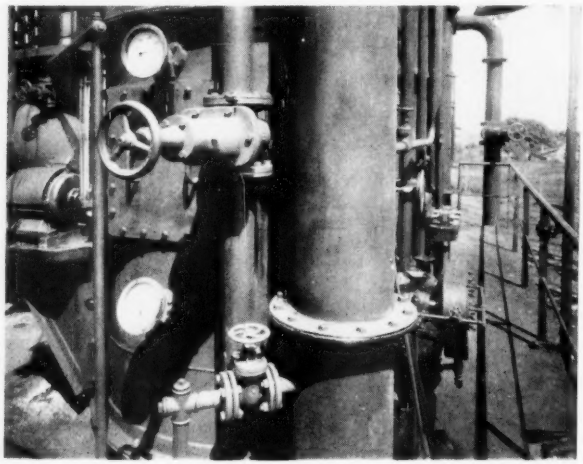

Fig. 3. The bottom of the pitch column. The pipes from the producer can be seen on the left of the picture

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fractions in the gas, the products flowing to a storage tank for cooling, recirculation and sale of surplus.

The gas, now free from dust, tar and all but a trace of light oil, is then boosted in a standard centrifugal type booster (5) running on ball and roller bearings and driven direct or through vee-ropes, by an electric motor. It should be noted that with this type of

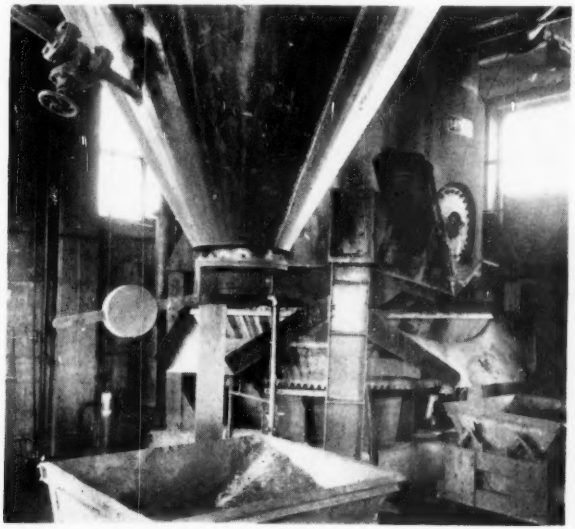


Fig. 4. View of the lower part of the producer and dust catcher

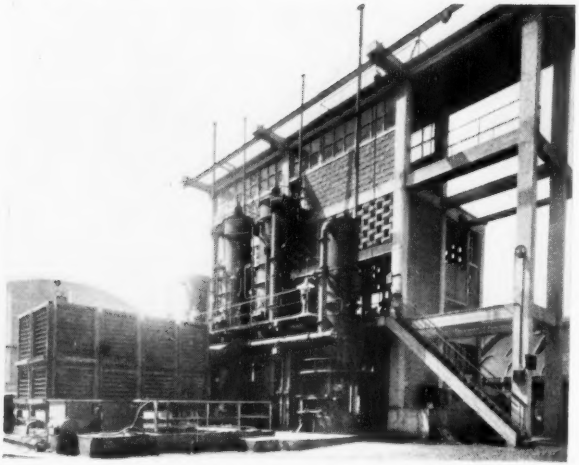


Fig. 5. General view showing cleaning plant, vats and cooling tower

cleaning there is no need for a complicated disintegrator, expensive both to buy and run.

Following the booster, the gas travels through a spray separator (6) to remove the remaining light oils and lastly to the final cooler (7). This may either be direct or indirect; the former is cheaper, but the latter has the advantage that the cooling water is uncontaminated and that the volume of effluent is small.

The gas, now at ambient temperature and containing only vestiges of water and light oil, is ready for piping to the furnaces. Should the plant be situated in a remote part of the works, the gas can, of course, be reboosted.

The hot tar and light oils from vessels (3) and (4) are collected in storage tanks, then pumped (9) and (10) through water coolers back to the cleaning vessels or the storage tank; the water used for cooling these products recovers some 80 per cent. of the sensible heat in the gas, and may be used as feed water or for space heating as desired.

The cleaning plant described will operate with any type of coal suitable for gasification. Should the present uncertain fuel position demand a change-over from bituminous coal to anthracite or coke, this can be carried out by water washing in the primary vessels, but the plant should be shut down and cleaned out before changing from bituminous to non-bituminous fuels, or vice versa.

The products of the new cleaning process are: (*a*) very clean gas; (*b*) water-free pitch and light oil; and (*c*) clean hot water. The layout of the plant is compact and convenient, and a high gross efficiency is obtained.

(Courtesy: "Metallurgia.")

RUBBER CONVEYOR AND ELEVATOR BELTING

THE British Standards Institution has just issued a revision of B.S.490, "Rubber conveyor and elevator belting."

The new document reverts, to a great extent, to the original standard of 1933, but now has five weights of fabric as well as three grades of rubber cover.

The standard also gives details regarding the construction of the belting as well as stipulating limits for defects, tolerance, strength of fabric and adhesion. Methods of test are given in the appendices, where information is also contained regarding suggestions for the selection of belting; the appendices also contain recommendations with regard to service conditions.

Additionally, an appendix is included stating the information which should be given with the enquiry.

In view of the present shortage of cotton, an amendment slip is being published simultaneously with the document, temporarily relaxing the strength of the fabric by 5 per cent.

Copies of this standard may be obtained from the British Standards Institution, price 3s. post free.

CERAMIC DRIERS

PART I

LEO WALTER,
A.M.I.Mech.E., M.Inst.F., A.M.I.Plant E.

IN the following, a general survey of recently developed drier types as used in the ceramic industry will be made.

Waste heat utilisation plays an important part as source of heat; for example, in drying sanitary ware, warm air from tunnel kilns is readily available for drying. Low-pressure exhaust steam or hot water are other waste heat media frequently utilised. Hot gases are another possible source for generation of hot air. They may be flue gases from kilns, boilers, gas generators, etc., and either shell-type heaters with gases flowing through tubes can be used for generation of hot air, or platen heat exchangers. Sometimes it is also possible to combine various sources of waste heat for generation of hot air, for example to use exhaust steam in an air-heater battery for producing warm air, and to boost up warm air temperature in a platen heat exchanger, using flue gases or Diesel exhaust gases as the heating medium.

Drier Types

A general classification of pottery driers according to design may be into tray driers, mangles, periodic truck driers, progressive tunnel systems, and infra-red driers. Another method of classification is into compartment driers, such as walk-in stores, chamber driers, rotating shelve types, or tunnel driers, using waste heat or exhaust steam, and conveyor driers, such as belt conveyor types, or chain conveyor types (mangles) using live or exhaust steam, or Town's gas. A few of these will now be discussed mainly from the thermal point of view.

For small batches various types of tray driers are in use. Usually the

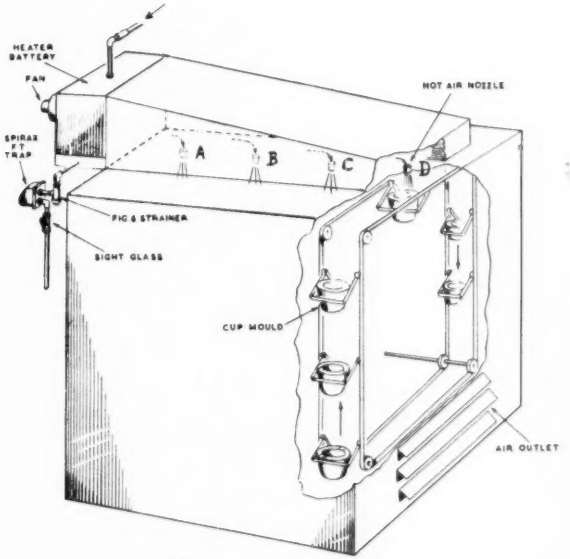


Fig. 1. Continuous pottery cup drier. A - D = hot air nozzles

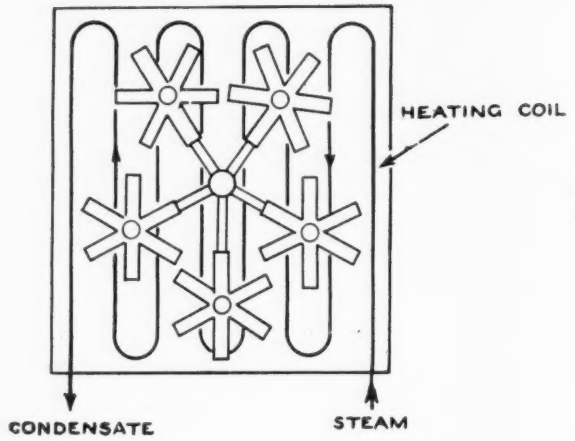
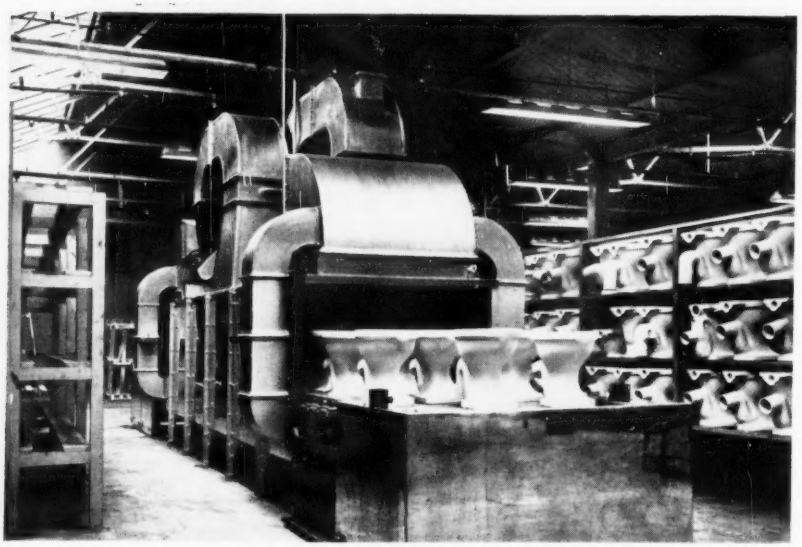


Fig. 2. Plan view of shelves and heating coil of revolving pottery stove

trays are loaded into a stationary cabinet where temperature should be carefully controlled. Tray driers, especially in the laboratory, can, however, be improved by increasing hot air velocity, and by altering direction of air flow by means of baffles. Humidity control by means of re-circulation dampers is another means for improving tray drier efficiency for large size older types. Introduction of re-circulation of air is, of course, the best precaution against too sharp drying. Rate of drying can sometimes be accelerated for certain types of drier by increasing air volume and hot air velocity by adding a unit heater, or by better steam trapping and air venting



(Courtesy, Hopol Ltd.)

Fig. 3. Tunnel drier for sanitary ware

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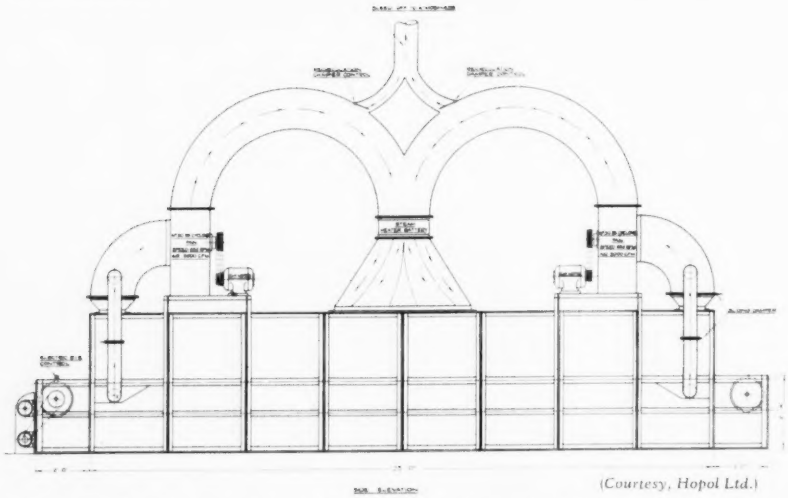
of the heater coils, and by improving insulation. Fitting an axial exhaust fan might sometimes increase output, or at least produce better air distribution, which is often required where "dead" spots are encountered, leaving the ware insufficiently dried.

Fig. 1 illustrates a continuous pottery cup drier, using hot air nozzles for performing a vigorous drying effect inside the cup. Efficient steam trapping of the air heater battery on top of the stove, and correct setting of the air outlet louvres will often considerably improve output. Introduction of re-circulation of air would probably improve heat consumption and controllability of drying rate, but is not easy to perform.

A diagrammatic plan view is illustrated in Fig. 2 of a steam-heated pottery stove with revolving shelves. Improvements might be possible by increasing the fall of the continuous steam heating coil towards the drain point, or by splitting the coil into two individually trapped sections. Output depends mainly on the rate of heat transfer from the coil surface to the air, and efficient steam trapping is recommendable. An additional unit heater might sometimes have beneficial results regarding hot air flow, and rate of drying.

More scientifically designed steam-heated pottery stoves use an air heater battery and hot air re-circulation. The most important factor for their operation is performance of humidity control by correctly adjusting the re-circulation damper. Thermostatic control can be performed by a thermostat, placed either in the outlet air duct, or alternatively in the inlet air duct, and actuating a steam control valve in the supply to the air heater battery on top of the stove. Larger potter's stoves with an inner pivotted frame, a heater battery on top and a hot air distribution chamber at the bottom are also widely used, having ware trays and rotating frames. The air flows vertically across the ware trays into an upper exhaust chamber. Fresh air is admixed via dampers in the re-circulation duct, and the air mixture is then re-heated.

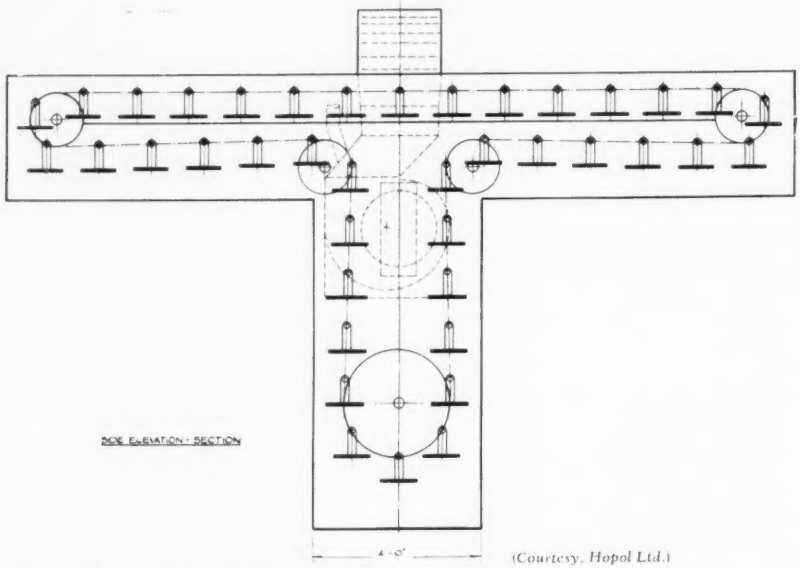
Where it is suspected that rate of



(Courtesy, Hopol Ltd.)

Fig. 4. Side elevation of tunnel drier as Fig. 3, showing dampers for regulating volume of re-circulation and of fresh air admixture

drying is not performed at the allowable top speed, it might sometimes pay to fit an additional small unit heater to the fresh air inlet, and to warm up the inlet air. Some sort of control of humidity of exhaust air via the exhaust air duct might also be useful in practice, because it could thus be

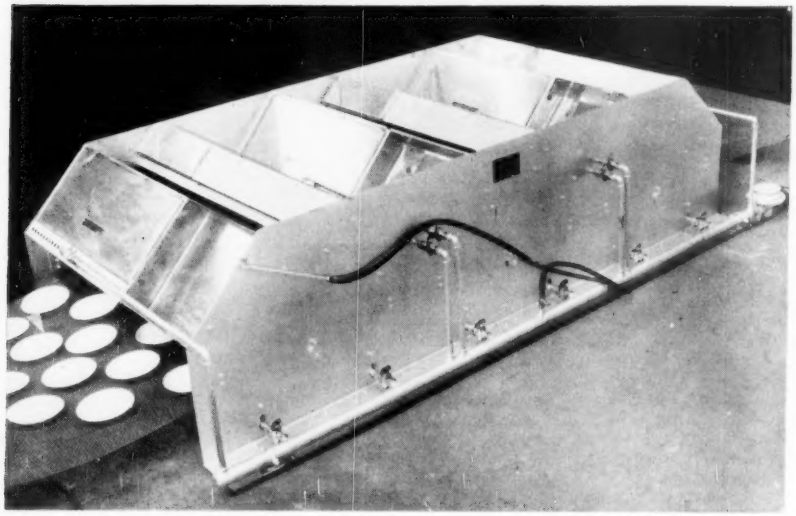


(Courtesy, Hopol Ltd.)

Fig. 5. Side elevation-section, of dipper drier, with down draught re-circulation, for handling production of two operatives

ensured that only air is exhausted which has (a) given up most of its heat, i.e., has low exhaust air temperature, and (b) has absorbed the maximum possible amount of moisture, i.e., has a high relative humidity. A suitable hydrometer-thermometer fitted into the exhaust air duct might serve as a guide to the operator for damper adjustment.

Increased output from making machines now favours continuous driers. For example, periodic truck driers are being applied, where the ware is loaded on trucks. The latter Monorail tunnel drier for sanitary ware. Proctor tunnel truck driers have also been developed for moulded insulators, and for crucibles. Air circulation within the drying space is carefully balanced in order to provide the same rate of evaporation on all surfaces of the ware. Precise automatic control of exhaust air dampers enables progressive humidity control as the air moves across the drier, and a careful drying schedule can be strictly adhered to. Conveyor belt driers for handled cups and for glaze-dipped china have also been designed



(Courtesy, Isratt Colbran Ltd.)

Fig. 6. Infra-red drier for glaze

are placed inside the drying enclosure, and obviously quick loading and unloading will be beneficial for output.

A further development, now widely used in America, and also being favoured in this country are continuous driers, such as progressive tunnel systems. One of the pioneers have been Proctor and Schwartz, producing mould release tunnel drier types with Monorail trucks, whereby overhead chains move the loaded trucks through the tunnel. Another American design is a humidity drier for hand-pressed glass pots, etc., with zoning, or a for continuous operation. Hot air is blown downwards into the hollow-ware articles as they move along, and belt assembly adds to efficiency of these trays.

An interesting dipper tunnel drier of British design with air re-circulation for sanitary ware is illustrated in Figs. 3 and 4. Made by Hopol Ltd. for one of the larger suppliers. This type is a good example for correct air heating, air distribution and efficient re-circulation. The through-put is about 120 closets or lavatory basins per hour, after glaze spraying or dipping. Two

electric motors drive the Cyclone fans of 5,000 e.m.f. at 652 r.p.m. for re-circulated and fresh air mixture to the steam-heated battery and hot air ducts. Adjustable exhaust dampers regulate the amount of re-circulation by bleeding off used air from the return ducts to atmosphere.

An electric eye at the conveyor end controls the drive motor and stops the plant in case of load failure. Sliding dampers regulate volume of re-circulation and of fresh air admixture, as can be seen in Fig. 4.

Fig. 5 illustrates another Hopol design of a dipper drier with down draught re-circulation for handling the production of two operatives. The through-put is 2,000 pieces per hour of 5 in. and 8 in. flat ware. A Sturtevant centrifugal fan is driven by a 4 h.p. motor and re-circulates the air from the return duct to the steam-heated battery. An air distribution chute with baffles conveys the hot air to the ware, as shown. The ·66 h.p. drive motor works over a reduction gear on the conveyor.

An interesting gas-heated infra-red drier of modern design is shown in Fig. 6, using 6 Bratt Colbran industrial radiant heat units. It has replaced a less efficient hot air system, taking formerly 30 min. for glaze drying of flat ware, as compared with now 2-3 min. Six jet burners are in use, and the side plates of the framework are made from $\frac{1}{8}$ M.S. material, but insulated with aluminium material. Reflector shields are used for distribution of radiant heat. A gas pressure regulator is installed, and the maximum gas rate for the infra-red drier is about 600 c. ft./hour. No cracking or distortion has been experienced in practice, thus confirming research results with relatively thin-walled articles, which lend themselves more readily to infra-red drying methods than first expected.

More Comment on Gas for the Potteries

COMMENTING on the decision of the West Midlands Gas Board not for the time being to allow the North Staffordshire pottery manufacturers a preferential tariff on gas fuel, equivalent to 1d. per therm above a given usage, Mr. Alec Maddock (chairman of the Gas Council of the British Pottery Manufacturers' Association, who introduced the Association deputation at the previous meeting) told the West Midlands Gas Consultative Council meeting at Birmingham that when the Association saw the report which the chairman of the Board had presented giving the reasons why no concession could be granted, they would be far from pleased.

A Masterly Report

While he might congratulate Mr. Diamond on a masterly report, he was afraid it did not help the pottery industry. However, it did mention that the Board would give the matter further consideration when the new and more uniform tariff system was finally set up later on. He intimated that this was a matter of the gravest concern to the pottery industry. As a matter of interest he might say that a manufacturer had begun firing with fuel oil, which was now cheaper than gas or electric firing, and he thought there would be repercussions —there was not the slightest doubt about it.

Mr. Diamond observed that the Board could only give them factual information at the moment, and this they had done as fully as possible, which Mr. Maddock said he appreciated. The chairman (Councillor W. H. Malcolm, J.P.) remarked that the request was to be given further and careful consideration, the Board undertaking to do so in the forming of the new tariff structure, when in its final stages. This structure, he gathered would possibly be presented early next year.

Mr. J. Fallon (Smethwick), after some comments on competitive fuel oil prices compared with gas in the future, said there were of course a number of electric kilns, but the cost of current per therm was more like 30d. he believed. Unfortunately all charges were going up, and selling prices had to follow, and to provide for replacements even profits.

Councillor H. Hewitt (Stoke-on-Trent)

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explained that it was on the cheap price of gas that the pottery industry manufacturers put down plant and tunnels for utilising this particular kind of fuel, and the Stoke gas works had been developed to meet these requirements. It was done at the cost of hundreds of thousands of pounds between them. Any change-over to oil fuel would of course cost pottery manufacturers a great deal of capital, and it was not merely a question of how many burners could be adopted. Although electricity was high in price, and cost more per therm than gas, it was more economical in its application to kilns, because so much heat did not go up the chimney, there was considerable wastage in this way in gas fumes which they did not experience in electricity.

The chairman said all members had received a copy of the report prepared by Mr. Diamond, and now knew what the position was. The Board could not see their way to grant any concession, yet, to the pottery manufacturers, and it was up to the council to decide whether they should approve or otherwise of the reply of the Gas Board. As the Board promised to give further consideration to the matter when submitting the new tariffs, that seemed as far as they could go. They had listened to the deputation, the case had been sent to the Board, and now they had an exhaustive report on the matter. He suggested that the report be sent to the Pottery Manufacturers' Association as the only course open to them at present.

Alderman Lewis (Birmingham) said the value of the Consumers' Council was shown by the fact that they are the medium through which the matters of this character could be brought forward. They all agreed it was a masterly report, for everyone could see where they stood, and they hoped something would be done in the future. It was then agreed to send the report to the Association, and Mr. Diamond was thanked for his comprehensive statement on the position.

GAS SCRUBBERS

FROM the Power-Gas Corporation Ltd., comes a leaflet describing the several types of gas scrubbers which they make for cleaning gas on all sorts of plant from the dry ice plant to the blast furnace. From this leaflet it would appear that Power-Gas have solved the problems of gas scrubbing in a manner which covers all fields right down to the sub-microm dust. This leaflet can be obtained from the Power-Gas Corporation Ltd., at Stockton-on-Tees.

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BOOK REVIEW

"Tablet Making," by Arthur Little and K. A. Mitchell. Northern Publishing Co. Ltd., Liverpool 1. 121 pp. and 41 illustrations. 15s.

Although this work on tablet making carries only two direct references to ceramics manufacture, it is, nevertheless, packed with "know how" relative to the production of small pressed shapes from powders of many kinds. To quote from the authors' foreword:

"Ceramics is an old industry in which the tablet machine is giving considerable assistance by speeding up production, since the advantages of 'dry' methods are becoming more widely known."

This reference, of course, is to the application of tablet-making technique in the shaping by press tool of the smaller items of electrical and technical porcelain. And in the chapters on Equipment, Mixing, Granulation and Compression, the man whose interests lie in this field will find many of his problems expertly dealt with.

Principles of tablet making are the same in each industry, and, as is perhaps to be expected in such a comprehensive work, considerable space is taken up by formulæ for use in the manufacture of tablets for the medical world. However, the interested ceramist may well consider this to be more than outweighed by the large amount of information which can be applied to his own special requirements—to say nothing of the generous number of illustrations of machines, plant and products with which the volume is provided.

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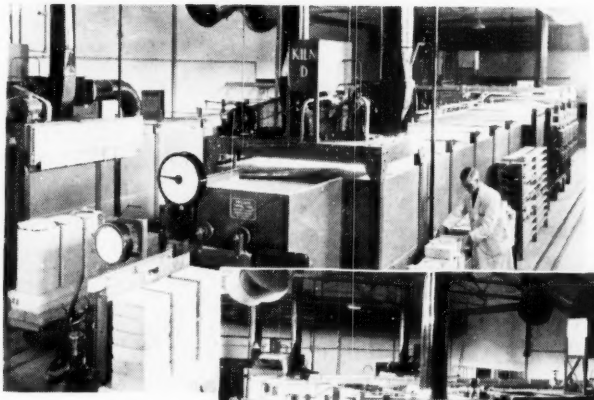

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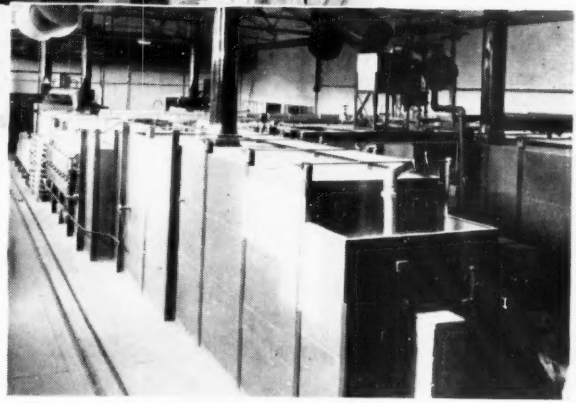

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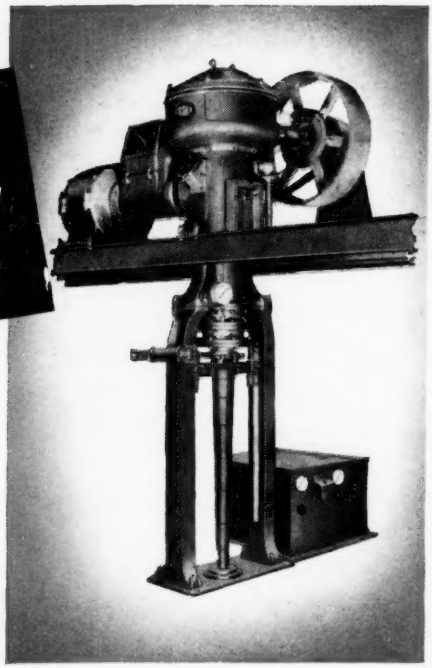

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